

THE NASTRAN USER'S MANUAL
(Level 16.0)

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INTRODUCTION

The User's Manual is one of four manuals that constitute the documentation for NASTRAN, the other three being the Theoretical Manual, the Programmer's Manual and the Demonstration Problem Manual. Although the User's Manual contains all of the information that is directly associated with the solution of problems with NASTRAN, the user will find it desirable to refer to the other manuals for assistance in the solution of specific user problems.

The Theoretical Manual is an excellent introduction to NASTRAN for those who are using NASTRAN for the first time. The User's Manual is restricted to those items related to the use of NASTRAN that are independent of the computing system being used. Computer dependent matters, such as operating system control cards, are treated in Section 5 of the Programmer's Manual. The Demonstration Problem Manual presents a discussion of the sample problems contained on the NASTRAN delivered User Master File (UMF).

NASTRAN uses a finite element structural model, wherein the distributed physical properties of a structure are represented by a finite number of structural elements which are interconnected at a finite number of grid points, to which loads are applied and for which displacements are calculated. The procedures for defining and loading a structural model are described in Section 1. This section contains a functional reference for every card that is used for structural modeling.

The NASTRAN Data Deck, including the details for each of the data cards, is described in Section 2. This section also discusses the NASTRAN control cards that are associated with the use of the program.

NASTRAN contains problem solution sequences, called rigid formats. Each of these rigid formats is associated with the solution of problems for a particular type of static or dynamic analysis. Section 3 contains a general description of rigid format procedures, along with specific instructions for the use of each rigid format.

The procedures for using the NASTRAN plotting capability are described in Section 4. Both deformed and undeformed plots of the structural model are available. Response curves are also available for transient response and frequency response analyses.

In addition to the rigid format procedures, the user may choose to write his own Direct Matrix Abstraction Program (DMAP). This procedure permits the user to execute a series of matrix operations of his choice along with any utility modules or executive operations that he may need. The rules governing the creation of DMAP programs are described in Section 5.

The NASTRAN diagnostic messages are documented and explained in Section 6. The NASTRAN Dictionary, in Section 7, contains descriptions of mnemonics, acronyms, phrases, and other commonly used NASTRAN terms.

There is a limited number of sample problems included in the User's Manual. However, a more comprehensive set of demonstration problems, at least one for each of the rigid formats, are described in the NASTRAN Demonstration Problem Manual. The data decks are available on tape, in the form of a User's Master file, for each of the computers on which NASTRAN has been implemented. Samples of the printer output and of structure plots and response plots can be obtained by executing these demonstration problems.

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STRUCTURAL MODELING

1.1 INTRODUCTION

NASTRAN embodies a lumped element approach, wherein the distributed physical properties of a structure are represented by a model consisting of a finite number of idealized substructures or elements that are interconnected at a finite number of grid points, to which loads are applied. All input and output data pertain to the idealized structural model. The major steps in the definition and loading of a structural model are indicated in Figure 1.

As indicated in Figure 1, the grid point definition forms the basic framework for the structural model. All other parts of the structural model are referenced either directly or indirectly to the grid points.

Two general types of grid points are used in defining the structural model. They are:

1. Geometric grid point - a point in three-dimensional space at which three components of translation and three components of rotation are defined. The coordinates of each grid point are specified by the user.
2. Scalar point - a point in vector space at which one degree of freedom is defined. Scalar points can be coupled to geometric grid points by means of scalar elements and by constraint relationships.

The structural element is a convenient means for specifying many of the properties of the structure, including material properties, mass distribution and some types of applied loads. In static analysis by the displacement method, stiffness properties are input exclusively by means of structural elements. Mass properties (used in the generation of gravity and inertia loads) are input either as properties of structural elements or as properties of grid points. In dynamic analysis, mass, damping, and stiffness properties may be input either as the properties of structural elements or as the properties of grid points (direct input matrices).

Structural elements are defined on connection cards by referencing grid points, as indicated on Figure 1. In a few cases, all of the information required to generate the structural matrices for the element is given on the connection card. In most cases the connection card refers to a property card, on which the cross-sectional properties of the element are given. The property card in turn refers to a material card which gives the material properties. If some of the material properties are stress dependent or temperature dependent, a further reference is made to tables for this information.

Various kinds of constraints can be applied to the grid points. Single-point constraints are used to specify boundary conditions, including enforced displacements of grid points.

STRUCTURAL MODELING

Multipoint constraints are used to specify a linear relationship among selected degrees of freedom, including the definition of infinitely rigid elements. Omitted points are used as a tool in matrix partitioning and for reducing the number of degrees of freedom used in dynamic analysis. Free-body supports are used to remove stress-free motions in static analysis and to evaluate the free-body inertia properties of the structural model.

Static loads may be applied to the structural model by concentrated loads at grid points, pressure loads on surfaces, or indirectly, by means of the mass and thermal expansion properties of structural elements are enforced deformations of one-dimensional structural elements. Due to the great variety of possible sources for dynamic loading, only general forms of loads are provided to the user in dynamic analysis.

The following sections describe the general procedures for defining structural models. Detailed instructions for each of the bulk data cards and case control cards are given in Section 2. Additional information on the case control cards and use of parameters is given for each rigid format in Section 3.

INTRODUCTION

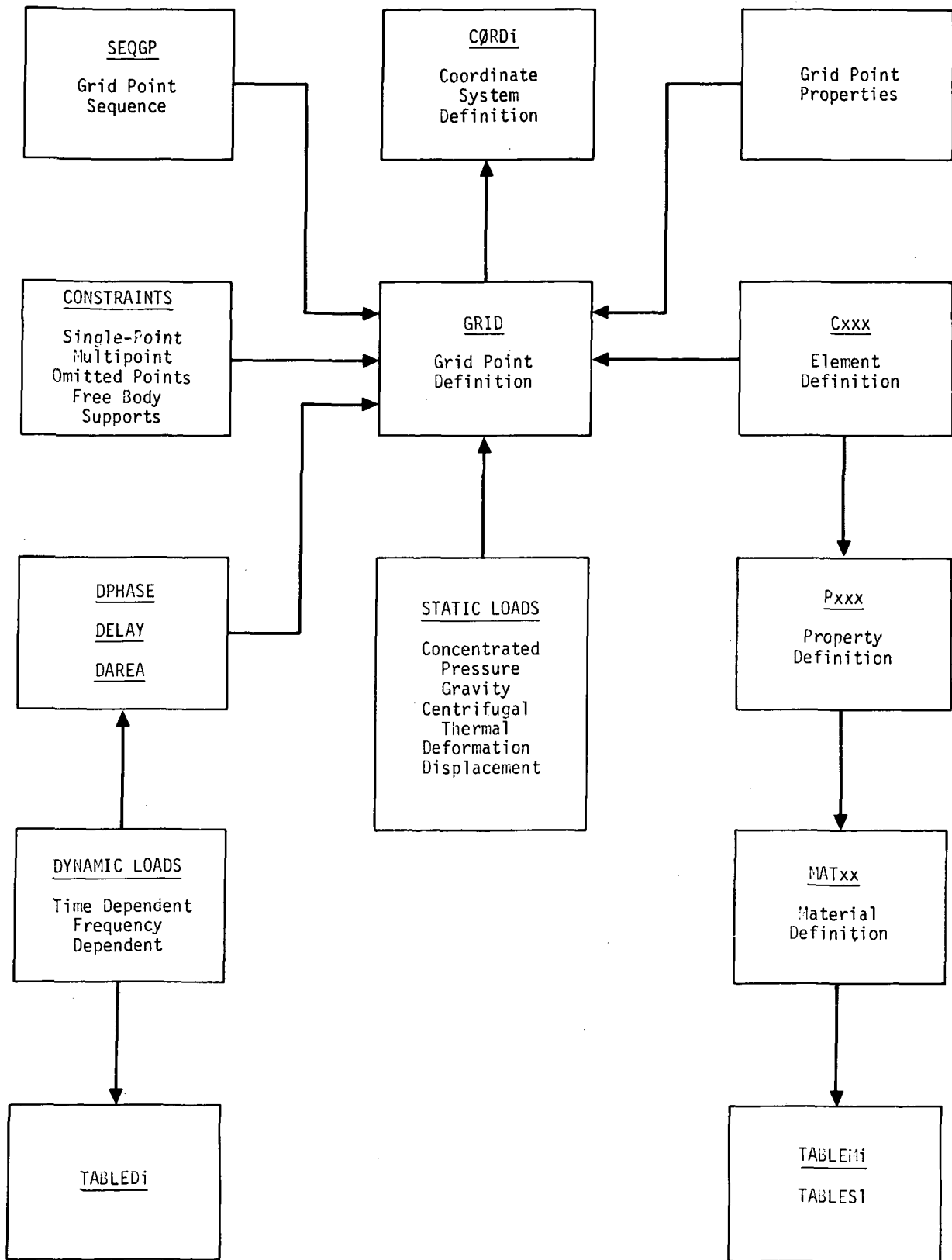


Figure 1. Structural model.

STRUCTURAL MODELING

1.2 GRID POINTS

1.2.1 Grid Point Definition

Geometric grid points are defined on GRID bulk data cards by specifying their coordinates in either the basic or a local coordinate system. The implicitly defined basic coordinate system is rectangular, except when using axisymmetric elements. Local coordinate systems may be rectangular, cylindrical, or spherical. Each local system must be related directly or indirectly to the basic coordinate system. The CØRD1C, CØRD1R and CØRD1S cards are used to define cylindrical, rectangular and spherical local coordinate systems, respectively, in terms of three geometric grid points which have been previously defined. The CØRD2C, CØRD2R and CØRD2S cards are used to define cylindrical, rectangular and spherical local coordinate systems, respectively, in terms of the coordinates of three points in a previously defined coordinate system.

Six rectangular displacement components (3 translations and 3 rotations) are defined at each grid point. The local coordinate system used to define the directions of motion may be different from the local coordinate system used to locate the grid point. Both the location coordinate system and the displacement coordinate system are specified on the GRID card for each geometric grid point. The orientation of displacement components depends on the type of local coordinate system used to define the displacement components. If the defining local system is rectangular, the displacement system is parallel to the local system and is independent of the grid point location as indicated in Figure 1a. If the local system is cylindrical, the displacement components are in the radial, tangential and axial directions as indicated in Figure 1b. If the local system is spherical, the displacement components are in the radial, meridional, and azimuthal directions as indicated in Figure 1c. Each geometric grid point may have a unique displacement coordinate system associated with it. The collection of all displacement coordinate systems is known as the global coordinate system. All matrices are formed and all displacements are output in the global coordinate system. The symbols T1, T2 and T3 on the printed output indicate translations in the 1, 2 and 3-directions, respectively, for each grid point. The symbols R1, R2 and R3 indicate rotations about the three axes.

Provision is also made on the GRID card to apply single-point constraints to any of the displacement components. Any constraints specified on the GRID card will be automatically used for all solutions. Constraints specified on the GRID card are usually restricted to those degrees of

STRUCTURAL MODELING

freedom that will not be elastically constrained and hence must be removed from the model in order to avoid singularities in the stiffness matrix.

The GRDSET card is provided to avoid the necessity of repeating the specification of location coordinate systems, displacement coordinate systems, and single-point constraints, when all, or many, of the GRID cards have the same entries for these items. When any of the 3 items are specified on the GRDSET card, the entries are used to replace blank fields on the GRID card for these items. This feature is useful in the case of such problems as space trusses where one wishes to remove all of the rotational degrees of freedom or in the case of plane structures where one wishes to remove all of the out-of-plane or all of the in-plane motions.

Scalar points are defined either on an SPØINT card or by reference on a connection card for a scalar element. SPØINT cards are used primarily to define scalar points appearing in constraint equations, but to which no structural elements are connected. A scalar point is implicitly defined if it is used as a connection point for any scalar element. Special scalar points, called "extra points", may be introduced for dynamic analyses. Extra points are used in connection with transfer functions and other forms of direct matrix input used in dynamic analyses and are defined on EPØINT cards.

GRIDB is a variation of the GRID card that is used to define a point on a fluid-structure interface (see Section 1.7).

1.2.2 Grid Point Sequencing

The best decomposition and equation solution times are obtained if the grid points can be sequenced in such a manner as to create matrices having small numbers of active columns (see Section 2.2 of the Theoretical Manual for a discussion of active columns and the decomposition algorithm). The decomposition time is proportional to the sum of the squares of the number of active columns in each row of the triangular factor. The equation solution time (forward/backward substitution) is proportional to the number of nonzero terms in the triangular factor.

In selecting the grid point sequencing it is not important to find the best sequence, rather it is usually quite satisfactory to find a good sequence, and to avoid bad sequences that create unreasonably large numbers of active columns. For many problems a sequence which will result in a band matrix is a reasonably good choice, but not necessarily the best. Also, sequences which result in small numbers of columns with nonzero terms are usually good but not necessarily the best.

GRID POINTS

A sequence with a larger number of nonzero columns will frequently have a smaller number of nonzero operations in the decomposition when significant passive regions exist within the active columns (see Section 2.2 of the Theoretical Manual).

Examples of proper grid point sequencing for one-dimensional systems are shown in Figure 2. For open loops a consecutive numbering system should be used as shown in Figure 2a. This sequencing will result in a narrow band matrix with no new nonzero terms created during the triangular decomposition. Generally, there is an improvement in the accumulated round off error if the grid points are sequenced from the flexible end to the stiff end.

For closed loops the grid points may be sequenced either as shown in Figure 2b or as shown in Figure 2c. If the sequencing is as shown in Figure 2b, the semiband will be twice that of the model shown in Figure 2a. The matrix will initially contain a number of zeroes within the band which will become nonzero as the decomposition proceeds. If the sequencing is as shown in Figure 2c, the band portion of the matrix will be the same as that for Figure 2a. However, the connection between grid points 1 and 8 will create a number of active columns on the right hand side of the matrix. The solution times will be the same for the sequence shown in Figure 2b or 2c, because the number of active columns in each sequence is the same.

Examples of grid point sequencing for surfaces are shown in Figure 3. For plain or curved surfaces with a pattern of grid points that tends to be rectangular, the sequencing shown in Figure 3a will result in a band matrix having good solution times. The semiband will be proportional to the number of grid points along the short direction of the pattern. If the pattern of grid points shown in Figure 3a is made into a closed surface by connecting grid points 1 and 17, 2 and 18, etc., a number of active columns equal to the semiband will be created. If the number of grid points in the circumferential direction is greater than twice the number in the axial direction, the sequencing indicated in Figure 3a is a good one. However, if the number of grid points in the circumferential direction is less than twice the number in the axial direction, the use of consecutive numbering in the circumferential direction is more efficient. An alternate sequencing for a closed loop is shown in Figure 3b, where the semiband is proportional to twice the number of grid points in a row. For cylindrical or similar closed surfaces, the sequencing shown in Figure 3b has no advantage over that shown in Figure 3a, as the total number of active columns will be the same in either case.

STRUCTURAL MODELING

With the exception of the central point, sequencing considerations for the radial pattern shown in Figure 3c are similar to those for the rectangular patterns shown in Figures 3a and 3b. The central point must be sequenced last in order to limit the number of active columns associated with this point to the number of degrees of freedom at the central point. If the central point is sequenced first, the number of active columns associated with the central point will be proportional to the number of radial lines. If there are more grid points on a radial line than on a circumferential line, the consecutive numbering should extend in the circumferential direction beginning with the outermost circumferential ring. In this case, the semiband is proportional to the number of grid points on a circumferential line and there will be no active columns on the right hand side of the matrix. If the grid points form a full circular pattern, the closure will create a number of active columns proportional to the number of grid points on a radial line if the grid points are numbered as shown in Figure 3c. Proper sequencing for a full circular pattern is similar to that discussed for the rectangular arrays shown in Figures 3a and 3b for closed surfaces.

Sequencing problems for actual structural models can frequently be handled by considering the model as consisting of several substructures. Each substructure is first numbered in the most efficient manner. The substructures are then connected so as to create the minimum number of active columns. The grid points at the interface between two substructures are usually given numbers near the end of the sequence for the first substructure and as near the beginning of the sequence for the second substructure as is convenient.

Figure 4 shows a good sequence for the substructure approach. Grid points 1 thru 9 are associated with the first substructure, and grid points 10 thru 30 are associated with the second substructure. In the example, each of the substructures was sequenced for band matrices. However, other schemes could also be considered for sequencing the individual substructures. Figure 5 shows the nonzero terms in the triangular factor. The X's indicate terms which are nonzero in the original matrix. The zeros indicate nonzero terms created during the decomposition. The maximum number of active columns for any pivotal row is only five, and this occurs in only three rows near the middle of the matrix for the second substructure. All other pivotal rows have four or less active columns.

Figure 6 indicates the grid point sequencing using substructuring techniques for a square model, and Figure 7 shows the nonzero terms in the triangular factor. If the square model were

GRID POINTS

sequenced for a band matrix, the number of nonzero terms in the triangular factor would be 129, whereas Figure 7 contains only 102 nonzero terms. The time for the forward/backward substitution operation is directly proportional to the number of nonzero terms in the triangular factor. Consequently, the time for the forward/backward substitution operation when the square array is ordered as shown in Figure 7 is only about 80% of that when the array is ordered for a band matrix. The number of multiplications for a decomposition when ordered for a band is 294, whereas the number indicated in Figure 7 is only 177. This indicates that the time for the decomposition when ordered as shown in Figure 6 is only 60% of that when ordered for a band.

Although scalar points are defined only in vector space, the pattern of the connections is used in a manner similar to that of geometric grid points for sequencing scalar points among themselves or with geometric grid points. Since scalar points introduced for dynamic analysis (extra points) are defined in connection with direct input matrices, the sequencing of these points is determined by direct reference to the positions of the added terms in the dynamic matrices.

The external identification numbers used for grid points may be selected in any manner the user desires. However, in order to reduce the number of active columns, and, hence, to substantially reduce computing times when using the displacement method, the internal sequencing of the grid points must not be arbitrary. In order to allow arbitrary grid point numbers and still preserve sparsity in the triangular decomposition factor to the greatest extent possible, provision is made for the user to resequence the grid point numbers for internal operations. This feature also makes it possible to easily change the sequence if a poor initial choice is made. All output associated with grid points is identified with the external grid point numbers. The SEQGP card is used to resequence geometric grid points and scalar points. The SEQEP card is used to sequence the extra points in with the previously sequenced grid points and scalar points.

STRUCTURAL MODELING

1.2.3 Grid Point Properties

Some of the characteristics of the structural model are introduced as properties of grid points, rather than as properties of structural elements. Any of the various forms of direct matrix input are considered as describing the structural model in terms of properties of grid points.

Thermal fields are defined by specifying the temperatures at grid points. The TEMP card is used to specify the temperature at grid points for use in connection with thermal loading and temperature dependent material properties. The TEMPD card is used to specify a default temperature, in order to avoid a large number of duplicate entries on a TEMP card when the temperature is uniform over a large portion of the structure. The TEMPAX card is used for conical shell problems.

Mass properties may be input as properties of grid points by using the concentrated mass element (see Section 5.5 of the Theoretical Manual). The CØNM1 card is used to define a 6x6 matrix of mass coefficients at a geometric grid point in any selected coordinate system. The CØNM2 card is used to define a concentrated mass at a geometric grid point in terms of its mass, the three coordinates of its center of gravity, the three moments of inertia about its center of gravity, and its three products of inertia, referred to any selected coordinate system.

In dynamic analysis, mass, damping, and stiffness properties may be provided, in part or entirely, as properties of grid points through the use of direct input matrices. The DMIG card is used to define direct input matrices for use in dynamic analysis. These matrices may be associated with components of geometric grid points, scalar points, or extra points introduced for dynamic analysis. The TF card is used to define transfer functions that are internally converted to direct matrix input. The DMIAX card is an alternate form of direct matrix input that is used for hydroelastic problems (see Section 1.7).

GRID POINTS

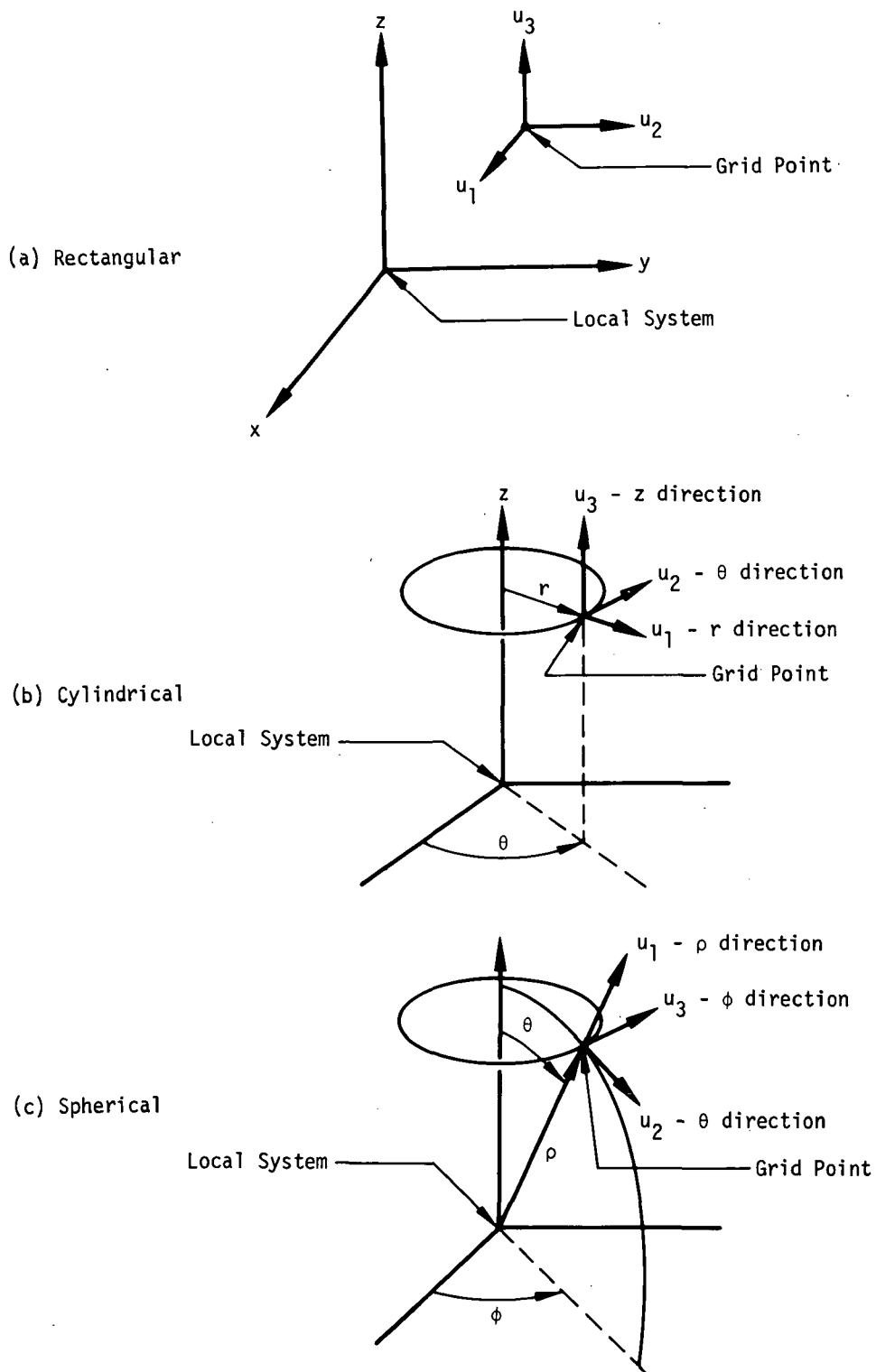


Figure 1. Displacement coordinate systems.

STRUCTURAL MODELING

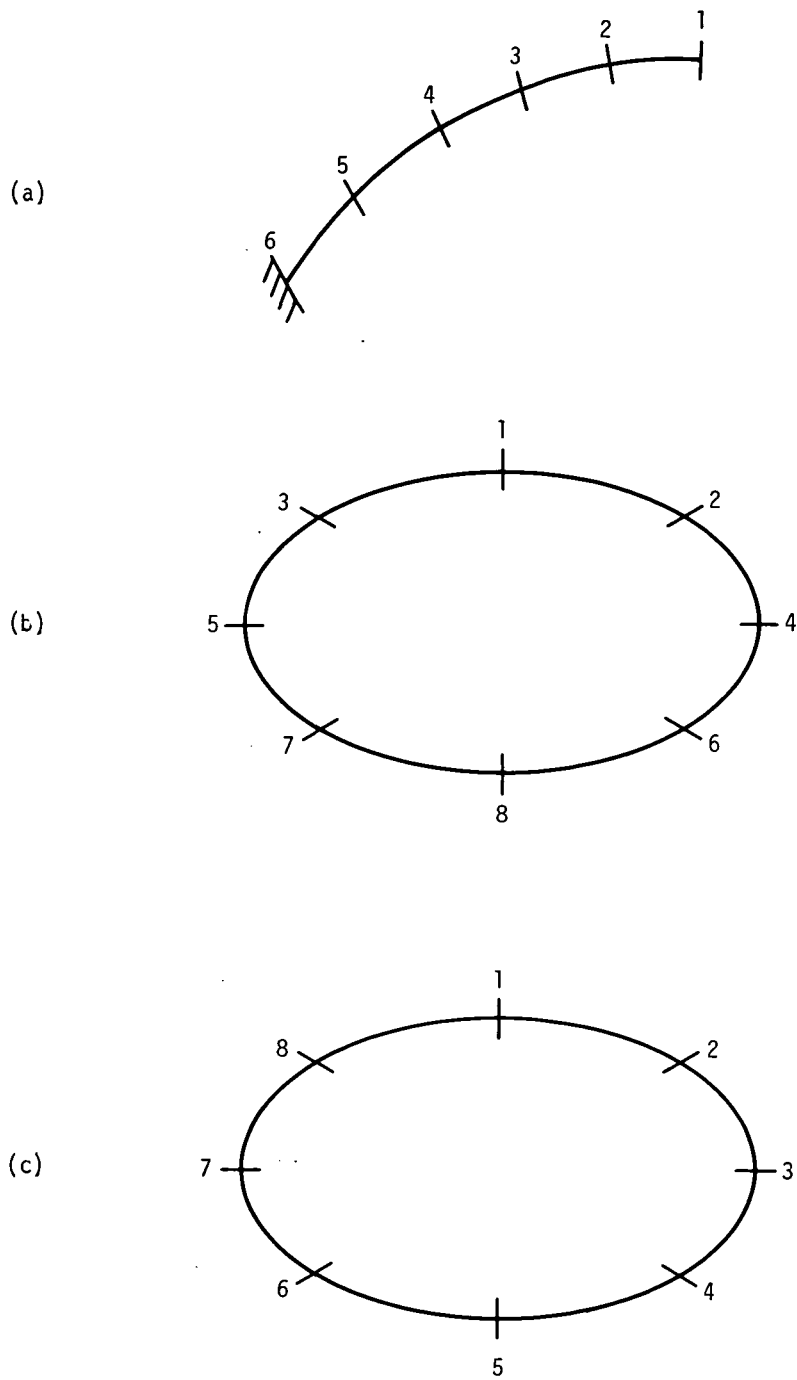
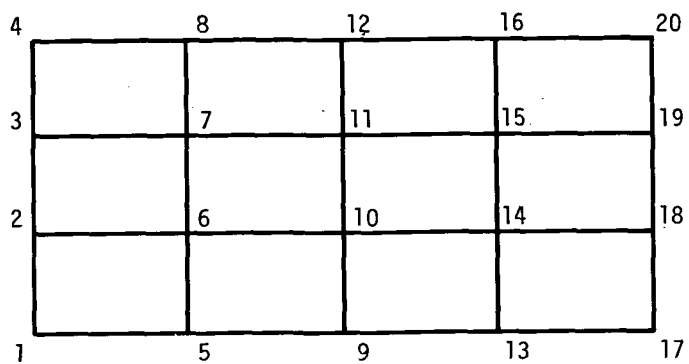


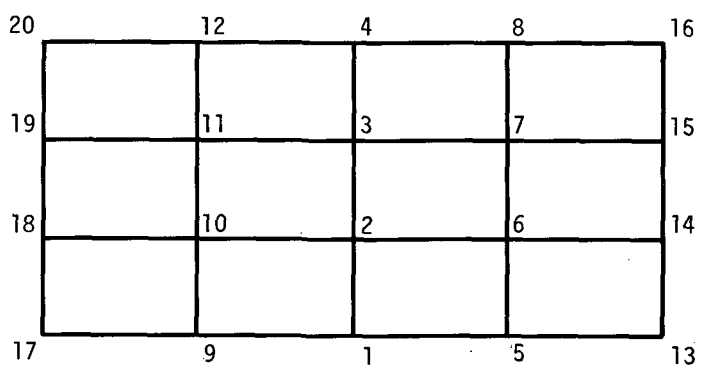
Figure 2. Grid point sequencing for one-dimensional systems.

GRID POINTS

(a)



(b)



(c)

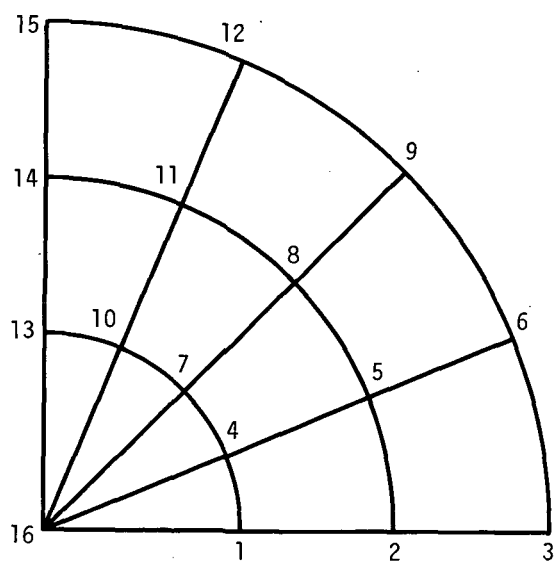


Figure 3. Grid point sequencing for surfaces.

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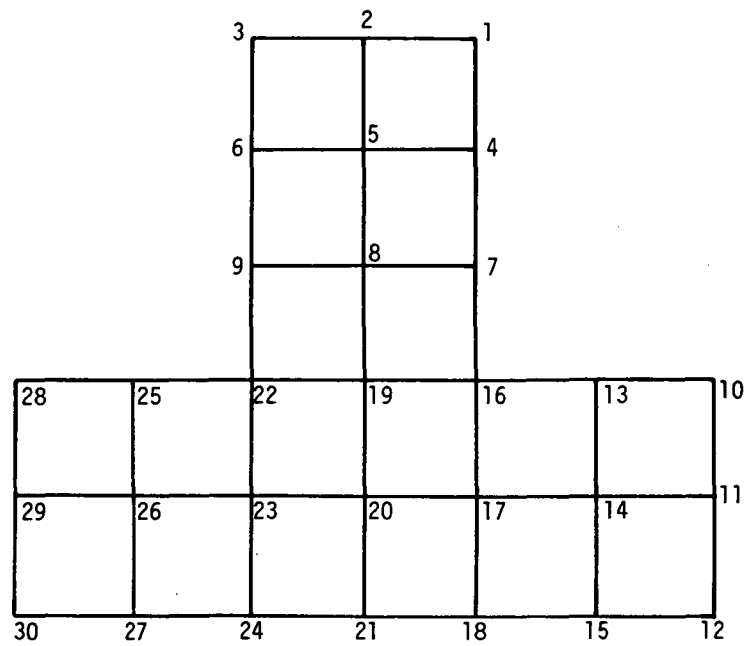


Figure 4. Grid point sequencing for substructures

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(Symmetric)

Figure 5. Matrix for substructure example

GRID POINTS

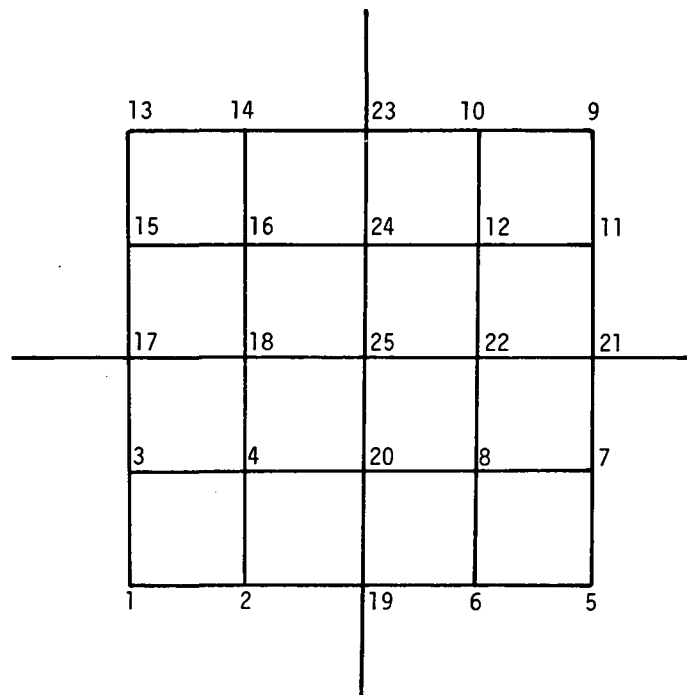


Figure 6. Grid point sequencing for square model

GRID POINTS

```

X  X  X
  X  O  X
    X  X
      X
        X  X  X
          X  O  X
            X  X
              X
                X  X  X
                  X  O  X
                    X  X
                      X
                        X  X  X
                          X  O  X
                            X  X  X
                              X  O  X
                                X  X  O  O
                                  X  O  O
                                    X  X  O  O  O  O  O
                                      X  O  O  O  O  O  X
                                        X  X  O  O  O
                                          X  O  O  X
                                            X  X  O
                                              X  X
                                                X

```

(Symmetric)

Figure 7. Matrix for square model example

STRUCTURAL MODELING

1.3 STRUCTURAL ELEMENTS

1.3.1 Element Definition

Structural elements are defined on connection cards that identify the grid points to which the element is connected. The mnemonics for all such cards have a prefix of the letter "C", followed by an indication of the type of element, such as CBAR and CRØD. The order of the grid point identification defines the positive direction of the axis of a one-dimensional element and the positive surface of a plate element. The connection cards include additional orientation information when required. Except for the simplest elements, each connection card references a property definition card. If many elements have the same properties, this system of referencing eliminates a large number of duplicate entries.

The property definition cards define geometric properties such as thicknesses, cross-sectional areas, and moments of inertia. The mnemonics for all such cards have a prefix of the letter "P", followed by some, or all of the characters used on the associated connection card, such as PBAR and PRØD. Other included items are the nonstructural mass and the location of points where stresses will be calculated. Except for the simplest elements, each property definition card will reference a material property card.

In some cases, the same finite element can be defined by using different bulk data cards. These alternate cards have been provided for user convenience. In the case of a rod element, the normal definition is accomplished with a connection card (CRØD) which references a property card (PRØD). However, an alternate definition uses a CØNRØD card which combines connection and property information on a single card. This is more convenient if a large number of rod elements all have different properties.

In the case of plate elements, a different property card is provided for each type of element, such as membrane or sandwich plates. Thus, each property card contains only the information required for a single type of plate element, and in most cases, a single card has sufficient space for all of the property information. In order to maintain uniformity in the relationship between connection cards and property cards, a number of connection card types contain the same information, such as the connection cards for the various types of triangular elements. Also, the property cards for triangular and quadrilateral elements of the same type contain the same information.

STRUCTURAL MODELING

The material property definition cards are used to define the properties for each of the materials used in the structural model. The MAT1 card is used to define the properties for isotropic materials. The MAT1 card may be referenced by any of the structural elements. The MATS1 card specifies table references for isotropic material properties that are stress dependent. The TABLES1 card defines a tabular stress-strain function for use in Piecewise Linear Analysis. The MATT1 card specifies table references for isotropic material properties that are temperature dependent. The TABLEM1, TABLEM2, TABLEM3, and TABLEM4 cards define four different types of tabular functions for use in generating temperature-dependent material properties.

The MAT2 card is used to define the properties for anisotropic materials. The MAT2 card may only be referenced by triangular or quadrilateral membrane and bending elements. The MAT2 card specifies the relationship between the inplane stresses and strains. The material is assumed to be infinitely rigid in transverse shear. The angle between the material coordinate system and the element coordinate system is specified on the connection cards. The MATT2 card specifies table references for anisotropic material properties that are temperature dependent. This card may reference any of the TABLEM1, TABLEM2, TABLEM3, or TABLEM4 cards.

The MAT3 card is used to define the properties for orthotropic materials used in the modeling of axisymmetric shells. This card may only be referenced by CTRIARG, CTRIAAX, CTRAPRG, CTRAPAX and PTORDRG cards. The MATT3 card specifies table references for use in generating temperature-dependent properties for this type of material.

The GENEL card is used to define general elements whose properties are defined in terms of deflection influence coefficients or stiffness matrices, and which can be connected between any number of grid points. One of the important uses of the general element is the representation of part of a structure by means of experimentally measured data. No output data is prepared for the general element. Detail information on the general element is given in Section 5.7 of the Theoretical Manual.

Dummy elements are provided in order to allow the user to investigate new structural elements with a minimum expenditure of time and money. A dummy element is defined with a CDUMi (i = index of element type, $1 \leq i \leq 9$) card and its properties are defined with the PDUMi card. The ADUMi card is used to define the items on the connection and property cards. Detail instructions for coding dummy element routines are given in Section 6.8.5 of the Programmer's Manual.

STRUCTURAL ELEMENTS

1.3.2 Bar Element

The bar element is defined with a CBAR card and its properties (constant over the length) are defined with a PBAR card. The bar element includes extension, torsion, bending in two perpendicular planes, and the associated shears. The shear center is assumed to coincide with the elastic axis. Any five of the six forces at either end of the element may be set equal to zero by using the pin flags on the CBAR card. The integers 1 to 6 represent the axial force, shearing force in Plane 1, shearing force in Plane 2, axial torque, moment in Plane 2, and moment in Plane 1, respectively. The structural and nonstructural mass of the bar are lumped at the ends of the elements, unless coupled mass is requested with the PARAM card C0UPMASS (see PARAM bulk data card). Theoretical aspects of the bar element are treated in Section 5.2 of the Theoretical Manual.

STRUCTURAL ELEMENTS

The element coordinate system is shown in Figure 1a. End a is offset from grid point a an amount measured by vector \vec{w}_a and end b is offset from grid point b an amount measured by vector \vec{w}_b . The vectors \vec{w}_a and \vec{w}_b are measured in the global coordinates of the connected grid point. The x-axis of the element coordinate system is defined by a line connecting end a to end b of the bar element. The orientation of the bar element is described in terms of two reference planes. The reference planes are defined with the aid of vector \vec{v} . This vector may be defined directly with three components in the global system at end a of the bar or by a line drawn from end a to a third referenced grid point. The first reference plane (Plane 1) is defined by the x-axis and the vector \vec{v} . The second reference plane (Plane 2) is defined by the vector cross product $(\vec{x} \times \vec{v})$ and the x-axis. The subscripts 1 and 2 refer to forces and geometric properties associated with bending in planes 1 and 2 respectively. The reference planes are not necessarily principal planes. The coincidence of the reference planes and the principal planes is indicated by a zero product of inertia (I_{12}) on the PBAR card. If shearing deformations are included, the reference axes and the principal axes must coincide. When pin flags and offsets are used, the effect of the pin is to free the force at the end of the element x-axis of the beam, not at the grid point. The positive directions for element forces are shown in Figure 1b. The following element forces, either real or complex (depending on the rigid format), are output on request:

1. Bending moments at both ends in the two reference planes.
2. Shears in the two reference planes.
3. Average axial force.
4. Torque about the bar axis.

The following real element stresses are output on request:

1. Average axial stress.
2. Extensional stress due to bending at four points on the cross-section at both ends. (Optional, calculated only if user enters stress recovery points on PBAR card.)
3. Maximum and minimum extensional stresses at both ends.
4. Margins of safety in tension and compression for the whole element. (Optional, calculated only if user enters stress limits on MAT1 card.)

Tensile stresses are given a positive sign and compressive stresses a negative sign. Only the average axial stress and the extensional stresses due to bending are available as complex stresses. The stress recovery coefficients on the PBAR card are used to locate points on the cross-section for stress recovery. The subscript 1 is associated with the distance of a stress recovery point from plane 2. The subscript 2 is associated with the distance from plane 1.

STRUCTURAL MODELING

The use of the BARØR card avoids unnecessary repetition of input when a large number of bar elements either have the same property identification number or have their reference axes oriented in the same manner. This card is used to define default values on the CBAR card for the property identification number and the orientation vector for the reference axes. The default values are used only when the corresponding fields on the CBAR card are blank.

1.3.3 Rod Element

The rod element is defined with a CRØD card and its properties with a PRØD card. The rod element includes extensional and torsional properties. The CØNRØD card is an alternate form that includes both the connection and property information on a single card. The tube element is a specialized form that is assumed to have a circular cross-section. The tube element is defined with a CTUBE card and its properties with a PTUBE card. The structural and nonstructural mass of the rod are lumped at the adjacent grid points unless coupled mass is requested with the PARAM card CØUPMASS (see PARAM bulk data card). Theoretical aspects of the rod element are treated in Section 5.2 of the Theoretical Manual).

The x-axis, of the element coordinate system, is defined by a line connecting end a to end b as shown in Figure 2. The axial force and torque are output on request in either the real or complex form. The positive directions for these forces are indicated in Figure 2. The following real element stresses are output on request:

1. Axial stress
2. Torsional stress
3. Margin of safety for axial stress
4. Margin of safety for torsional stress.

Positive directions are the same as those indicated in Figure 2 for element forces. Only the axial stress and the torsional stress are available as complex stresses.

Another kind of rod element is the viscous damper, that has extensional and torsional viscous damping properties rather than stiffness properties. The viscous damper element is defined with a CVISC card and its properties with a PVISC card. This element is used in the direct formulation of dynamic matrices.

STRUCTURAL ELEMENTS

1.3.4 Shear Panels and Twist Panels

The shear panel is defined with a CSHEAR card and its properties with a PSHEAR card. A shear panel is a two-dimensional structural element that resists the action of tangential forces applied to its edges, but does not resist the action of normal forces. The structural and nonstructural mass of the shear panel are lumped at the connected grid points. Details of the shear panel element are discussed in Section 5.3 of the Theoretical Manual.

The element coordinate system for a shear panel is shown in Figure 3a. The integers 1, 2, 3, and 4 refer to the order of the connected grid points on the CSHEAR card. The element forces are output on request in either the real or complex form. The positive directions for these forces are indicated in Figure 3b. These forces consist of the forces applied to the element at the corners in the direction of the sides, kick forces at the corners in a direction normal to the plane formed by the two adjacent edges, and "shear flows" (force per unit length) along the four edges. The shear stresses are calculated at the corners in skewed coordinates parallel to the exterior edges. The average of the four corner stresses and the maximum stress are output on request in either the real or complex form. A margin of safety is also output when the stresses are real.

The twist panel performs the same function for bending action that the shear panel performs for membrane action. The twist panel is defined with a CTWIST card and its properties with a PTWIST card. In calculating the stiffness matrix, a twist panel is assumed to be solid. For built-up panels, the thickness in the PTWIST card must be adjusted to give the correct moment of inertia of the cross-section. If mass calculations are being made, the density will also have to be adjusted on a MAT1 card. The element coordinate system and directions for positive forces are shown in Figure 4. Stress recovery is similar to that for shear panels.

1.3.5 Plate Elements

NASTRAN includes two different shapes of plate elements (triangular and quadrilateral) and two different stress systems (membrane and bending) which are uncoupled. There are in all a total of eleven different forms of plate elements that are defined by connection cards as follows:

1. CTRMEM - triangular element with finite inplane stiffness and zero bending stiffness.
2. CTRBSC - basic unit from which the bending properties of the other plate elements are formed.
3. CTRPLT - triangular element with zero inplane stiffness and finite bending stiffness.
4. CTRIAL - triangular element with both inplane and bending stiffness. It is designed for sandwich plates which can have different materials referenced for membrane, bending and transverse shear properties.

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5. CTRIA2 - triangular element with both inplane and bending stiffness that assumes a solid homogeneous cross section.
6. CQDMEM - quadrilateral element consisting of four overlapping CTRMEM elements.
7. CQDMEM1 - an isoparametric quadrilateral membrane element.
8. CQDMEM2 - a quadrilateral membrane element consisting of four nonoverlapping CTRMEM elements.
9. CQDPLT - quadrilateral element with zero inplane stiffness and finite bending stiffness.
10. CQUAD1 - quadrilateral element with both inplane and bending stiffness. It is designed for sandwich plates which can have different materials referenced for membrane, bending and transverse shear properties.
11. CQUAD2 - quadrilateral element with both inplane and bending stiffness that assumes a solid homogeneous cross section.

Theoretical aspects of the plate elements are treated in Section 5.8 of the Theoretical Manual.

The properties for the above elements are defined on the PTRMEM, PTRBSC, PTRPLT, PTRIA1, PTRIA2, PQDMEM, PQDMEM1, PQDMEM2, PQDPLT, PQUAD1, and PQUAD2 cards respectively. Anisotropic material may be specified for all plate elements. Transverse shear flexibility may be included for all bending elements on an optional basis, except for homogeneous plates (CTRIA2 and CQUAD2), where this effect is automatically included. Structural mass is calculated only for elements that specify a membrane thickness and is based only on the membrane thickness. Nonstructural mass can be specified for all plate elements, except the basic bending triangle. Only lumped mass procedures are used for membrane elements. Coupled mass procedures may be requested for elements that include bending stiffness with the PARAM card C0UPMASS (see PARAM bulk data card). Differential stiffness matrices are generated for the following plate elements: CTRMEM, CTRIA1, CTRIA2, CQDMEM, CQUAD1, CQUAD2. The following plate elements may have nonlinear material characteristics in Piecewise Linear Analysis: CTRMEM, CTRIA1, CTRIA2, CQDMEM, CQUAD1, CQUAD2.

The element coordinate systems for triangular and quadrilateral plate elements are shown in Figure 5. The integers 1, 2, 3, and 4 refer to the order of the connected grid points on the connection cards defining the elements. The angle θ is the orientation angle for anisotropic materials.

Average values of element forces are calculated for all plate elements having a finite bending stiffness. The positive directions for plate element forces in the element coordinate system are shown in Figure 6a. The following element forces per unit of length, either real or complex, are output on request:

STRUCTURAL ELEMENTS

1. Bending moments on the x and y faces.
2. Twisting moment.
3. Shear forces on the x and y faces.

The CQDMEM2 is the only membrane element for which element forces are calculated. The positive directions for these forces are shown in Figure 3b, and the force output has the same interpretation as the force output for the shear panel discussed previously.

Average values of the membrane stresses are calculated for the triangular and quadrilateral membrane elements, with the exception of the CQDMEM1 element. For the CQDMEM1 element, in which the stress field varies, the stresses are evaluated at the intersection of diagonals (in a mean plane if the element is warped). The positive directions for the membrane stresses are shown in Figure 6b. The stresses for the CQDMEM2 element are calculated in the material coordinate system. The material coordinate system is defined by the material orientation angle on the CQDMEM2 card. The stresses for all other membrane elements are calculated in the element coordinate system.

STRUCTURAL ELEMENTS

The following real membrane stresses are output on request:

1. Normal stresses in the x and y directions
2. Shear stress on the x face in the y direction
3. Angle between the x-axis and the major principal axis
4. Major and minor principal stresses
5. Maximum shear stress

Only the normal stresses and shearing stress are available in the complex form.

If the plate element has bending stiffness the average stresses are calculated on the two faces of the plate for homogeneous plates and at two specified points on the cross-section for other plate elements. The distances to the specified points are given on the property cards. The positive directions for these fiber distances are defined according to the right-hand sequence of the grid points specified on the connection card. These distances must be nonzero in order to obtain nonzero stress output. The same stresses are calculated for each of the faces as are calculated for membrane elements.

The quadrilateral plate elements are intended for use when the surfaces are reasonably flat and the geometry is nearly rectangular. For these conditions the quadrilateral elements eliminate the modeling bias associated with the use of triangular elements, and quadrilaterals give more accurate results for the same mesh size. If the surfaces are highly warped, curved or swept, triangular elements should be used. Under extreme conditions quadrilateral elements will give results that are considerably less accurate than triangular elements for the same mesh size. Quadrilateral elements should be kept as nearly square as practicable, as the accuracy tends to deteriorate as the aspect ratio of the quadrilateral increases. Triangular elements should be kept as nearly equilateral as practicable, as the accuracy tends to deteriorate as the triangles become obtuse and as the ratio of the longest to the shortest side increases.

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1.3.6 Axisymmetric Shell Elements

The properties of axisymmetric shells can be specified with either of two elements, the conical shell (CONEAX) or the toroidal ring (TORDRG). However, these cannot be used together in the same model. Also available for thick shells of revolution are the axisymmetric solid elements which are described in the next section.

The properties of the conical shell element are assumed to be symmetrical with respect to the axis of the shell. However, the loads and deflections need not be axisymmetric, as they are expanded in Fourier series with respect to the axial coordinate. Due to symmetry, the resulting load and deformation systems for different harmonic orders are independent, a fact that results in a large time saving when the use of the conical shell element is compared with an equivalent model constructed from plate elements. Theoretical aspects of the conical shell element are treated in Section 5.9 of the Theoretical Manual.

At present the conical shell element cannot be combined with other types of elements. The existence of a conical shell problem is defined by the AXIC card. This card also indicates the number of harmonics desired in the problem formulation. Only a limited number of bulk data cards are allowed when using conical shell elements. The list of allowable cards is given on the AXIC card description in Section 2.4.2.

The geometry of a problem using the conical shell element is described with RINGAX cards instead of GRID cards. The RINGAX cards describe concentric circles about the basic z-axis, with their locations given by radii and z-coordinates as shown in Figure 7. The degrees of freedom defined by each RINGAX card are the fourier coefficients of the motion with respect to angular position around the circle. For example the radial motion, u_r , at any angle, ϕ , is described by the equation:

$$u_r(\phi) = \sum_{n=0}^N u_r^n \cos n\phi + \sum_{n=0}^N u_r^{n*} \sin n\phi, \quad (1)$$

where u_r^n and u_r^{n*} are the fourier coefficients of radial motion for the n-harmonic. For calculation purposes the series is limited to N harmonics as defined by the AXIC card. The first sum in the above equation describes symmetric motion with respect to the $\phi = 0$ plane. The second sum with the "starred" (*) superscripts describes the antisymmetric motion. Thus each RINGAX data card will produce six times (N+1) degrees of freedom for each series.

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The selection of symmetric or antisymmetric solutions is controlled by the AXISYM card in the Case Control Deck. For general loading conditions, a combination of the symmetric and antisymmetric solutions must be made, using the SYMCØM card in the Case Control Deck (Section 2.3 of the User's Manual).

Since the user is rarely interested in applying his loads in terms of Fourier harmonics and interpreting his data by manually performing the above summations, NASTRAN is provided with special cards which automatically perform these operations. The PØINTAX card is used like a GRID card to define physical points on the structure for loading and output. Sections of the circle may be defined by a SECTAX card which defines a sector with two angles and a referenced RINGAX card. The PØINTAX and SECTAX cards define six degrees of freedom each. The basic coordinate system for these points is a cylindrical system (r, ϕ, z) and their applied loads must be described in this coordinate system. Since the displacements of these points are dependent on the harmonic motions, they may not be constrained in any manner.

The conical shell element is connected to two RINGAX points with a CCØNEAX card. The properties of the conical shell element are described on the PCØNEAX card. The RINGAX points must be placed on the neutral surface of the element and the points for stress calculation must be given on the PCØNEAX card relative to the neutral surface. Up to fourteen angular positions around the element may be specified for stress and force output. These values will be calculated midway between the two connected rings.

The structure defined with RINGAX and CCØNEAX cards must be constrained in a special manner. All harmonics may be constrained for a particular degree of freedom on a ring by using permanent single-point constraints on the RINGAX cards. Specified harmonics of each degree of freedom on a ring may be constrained with a SPCAX card. This card is the same as the SPC card except that a harmonic must be specified. The MPCAX, ØMITAX, and SUPAX data cards correspond to the MPC, ØMIT, and SUPØRT data except that harmonics must be specified. SPCADD and MPCADD cards may be used to combine constraint sets in the usual manner.

The stiffness matrix includes five degrees of freedom per grid circle per harmonic when transverse shear flexibility is included. Since the rotation about the normal to the surface is not included, either the fourth or the sixth degree of freedom (depending upon the situation) must be constrained to zero when the angle between the meridional generators of two adjacent elements is zero. When the transverse shear flexibility is not included, only four independent degrees of

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freedom are used and the fourth and sixth degrees of freedom must be constrained to zero for all rings. These constraints can be conveniently specified on the RINGAX card.

The conical shell structure may be loaded in various ways. Concentrated forces may be described by FØRCE and MØMENT cards applied to PØINTAX points. Pressure loads may be input in the PRESAX data card which defines an area bounded by two rings and two angles. Temperature fields are described by a paired list of angles and temperatures around a ring as required by the TEMPAX card. Direct loads on the harmonics of a RINGAX point are given by the FORCEAX and MØMAX card. Since the basic coordinate system is cylindrical the loads are given in the r , ϕ , and z directions. The value of a harmonic load F_n is the total load on the whole ring of radius r . If a sinusoidal load per unit length of maximum value a_n is given, the value on the FØRCEAX card must be

$$F_n = 2\pi r a_n \quad n = 0, \quad (2)$$

$$F_n = \pi r a_n \quad n > 0. \quad (3)$$

Displacements of rings and forces in conical shell elements can be requested in two ways:

1. The harmonic coefficients of displacements on a ring or forces in a conical element.
2. The displacements at specified points or the average value over a specified sector of a ring. The forces in the element at specified azimuths or average values over specified sectors of a conical element.

Harmonic output is requested by ring number for displacements and conical shell element number for element forces. The number of harmonics that will be output for any request is a constant for any single execution. This number is controlled by the HARMØNICS card in the Case Control Deck (see Section 2.3).

The following element forces per unit of width are output either as harmonic coefficients or at specified locations on request:

1. Bending moments on the u and v faces
2. Twisting moments
3. Shearing forces on the u and v faces

The following element stresses are calculated at two specified points on the cross-section of the element and output either as harmonic coefficients or at specified locations on request:

1. Normal stresses in u and v directions
2. Shearing stress on the u face in the v direction

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3. Angle between the u-axis and the major principal axis
4. Major and minor principal stresses
5. Maximum shear stress

The coordinate system for the toroidal ring is shown in Figure 8. This cylindrical coordinate system is implied by the use of the toroidal element, and hence, no explicit definition is required. The toroidal element may use orthotropic materials. The axes of orthotropy are assumed to coincide with the element coordinate axes.

Deformation behavior of the toroidal element is described by five degrees of freedom for each of the two grid rings which it connects. The degrees of freedom in the implicit coordinate system are:

1. \bar{u} - radial displacement
2. Not defined for toroidal element (must be constrained)
3. \bar{w} - axial displacement
4. $w' = \frac{\partial w}{\partial \xi}$ slope in ξ -direction
5. $u' = \frac{\partial u}{\partial \xi}$ strain in ξ -direction
6. $w'' = \frac{\partial^2 w}{\partial \xi^2}$ curvature in $z\xi$ -plane

The displacements \bar{u} and \bar{w} are in the basic coordinate system, and hence can be expressed in other local coordinate systems if desired. However, the quantities u' , w' and w'' are always in the element coordinate system.

The toroidal ring element connectivity is defined with a CTØRDRG card and its properties with a PTØRDRG card and, in the limit, this element becomes a cap element (see Section 5.10 of the Theoretical Manual). The integers 1 and 2 on Figure 8 refer to the order of the connected grid points on the CTØRDRG card. The grid points must lie in the $r\text{-}\bar{z}$ plane of the basic coordinate system and they must lie to the right of the axis of symmetry. The angles α_1 and α_2 in Figure 8 are the angles of curvature and are defined as the angle measured in degrees from the axis of symmetry to a line which is perpendicular to the tangent to the surface at grid points 1 and 2 respectively. For conic rings $\alpha_1 = \alpha_2$ and for cylindrical rings $\alpha_1 = \alpha_2 = 90$ degrees. Toroidal elements may be connected to form closed figures in the $r\text{-}\bar{z}$ plane, but slope discontinuities are not permitted at connection points.

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The following forces, evaluated at each end of the toroidal element, are output on request:

1. Radial force
2. Axial force
3. Meridional moment
4. A generalized force which corresponds to the w' degree of freedom.
5. A generalized force which corresponds to the w'' degree of freedom.

The first three forces are referenced to the global coordinate system and the two generalized forces are referenced to the element coordinate system. For a definition of the generalized forces see Section 5.10 of the Theoretical Manual.

The following stresses, evaluated at both ends and the midspan of each element, are output on request:

1. Tangential membrane stress (Force per unit length)
2. Circumferential membrane stress (Force per unit length)
3. Tangential bending stress (Moment per unit length)
4. Circumferential bending stress (Moment per unit length)
5. Shearing stress (Force per unit length)

The positive directions for these stresses are indicated in Figure 9.

1.3.7 Axisymmetric Solid Elements

Two sets of elements are provided for representing thick axisymmetric shell and/or solid structures (see Section 5.11 of the Theoretical Manual). The first set, the triangular ring TRIARG and trapezoidal ring TRAPRG, is restricted to axisymmetric applied loadings only. The second set is not restricted to axisymmetric loadings and, like the conical shell element, their displacements and loads are represented by coefficients of a Fourier series about the circumference. These elements, the TRIAAX and the TRAPAX, also define a triangular and a trapezoidal cross section respectively. The elements of one set may not be used together with elements of the other set nor with any other elements in NASTRAN.

The triangular and trapezoidal ring elements may be used for modeling axisymmetric thick-walled structures of arbitrary profile. In the limiting case only the TRAPRG element may become a solid core element.

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The coordinate system for the triangular ring element is shown on Figure 10. The cylindrical system is implied by the use of the triangular ring element. Hence, no explicit definition of the basic cylindrical coordinate system is required. Cylindrical anisotropy is optional for the material properties in the ring element. Orientation of the orthotropic axes in the (r,z) plane is specified by the angle θ . Deformation behavior of the element is described in terms of translations in the r and z directions at each of the 3 connected grid points. All other degrees of freedom must be constrained.

The triangular ring element is defined with a CTRIARG card. No property card is used for this element. The material property reference is given on the connection card. The integers 1, 2 and 3 on Figure 10 refer to the order of the connected grid points on the CTRIARG card. This order must be counter-clockwise around the element. The grid points must lie in the r - z plane of the basic cylindrical coordinate system, and they must lie to the right of the axis of symmetry.

The radial and axial forces at each connected grid point are output on request. The positive directions for these forces are shown in Figure 10. These are apparent element forces and they include any equivalent thermal loads. The stresses at the centroid of an element are output on request. The available quantities are the normal stresses in the radial, circumferential and axial directions, and the shear stress on the radial face in the axial direction. Positive stresses are in the positive direction on the positive face.

The coordinate system for the trapezoidal ring element is shown in Figure 11. This element is similar to the triangular ring element. This element has the additional restriction that the element numbering must begin at the lower left hand corner of the element. Also, the parallel faces of the trapezoid must be perpendicular to the axis of symmetry. This element can be used in the limiting case where the r coordinates associated with grid points 1 and 4 are zero. In this special case the element is referred to as a core element.

The trapezoidal ring element is defined with a CTRAPRG card in a manner similar to that for a triangular element. The forces at the four connected grid points are provided on request in a manner similar to that for a triangular element. In addition to providing the stresses at the four connected grid points of the trapezoid, similar stresses are provided at a point of average radius and average z -distance from the four points.

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The two solid of revolution elements which are provided for representing nonaxisymmetric loadings on axisymmetric structures with thick or solid cross sections are the TRIAAX and TRAPAX elements. These define a triangle and a trapezoidal cross section of the structure. They are functionally similar to the conical shell element (see Section 1.3.6) and physically similar to the axisymmetric ring elements CTRAPRG and CTIRARG described above (see Figures 10 and 11).

The elements are connected to RINGAX points which define displacement degrees of freedom represented by coefficients of a Fourier series about the circumference. Due to symmetry, the resulting load and deformation systems for the different harmonic orders are uncoupled, resulting in large time savings compared to a general three-dimensional model. Theoretical aspects of the solid of revolution elements are treated in Section 5.11 of the Theoretical Manual. Definitions of the Fourier series representation of the structural displacements and loads are given in Section 5.9 of the Theoretical Manual. As in the conical shell formulation, no other element types may be combined with these elements.

The following special case control cards, used also with the conical shell problem, are used with the solid of revolution elements:

AXISYM - Defines whether the cosine series, sine series or combination of displacements are to be calculated.

HARMONICS - Limits the output to all harmonics up to and including the n^{th} harmonic, default is 0.

The geometry of a problem using these elements is defined by the RINGAX cards. The harmonic limit in the Fourier expansion is defined by the required AXIC card. The RINGAX card does not allow a zero radius. However, a small "hole" may be defined around the axis of revolution. To avoid inaccuracies, a warning is issued for each element whose inner radius is less than one-tenth its outer radius. Property cards PTRAPAX and PTRIAAX are used to identify the material and the circumferential locations for stress output. The material type is limited to MAT1 and MAT3 definitions. The following bulk data cards, also used with the conical shell elements, are available with the solid of revolution elements:

AXIC - Defines limit of displacement Fourier series.

SPCAX - Defines single point constraints and enforced displacements on specified degrees of freedom.

MPCAX - Defines multipoint constraints connecting specified degrees of freedom.

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- ØMITAX - Defines degrees of freedom to be removed by structural partitioning.
- SUPAX - Defines free-body support points.
- PØINTAX - Defines circumferential location on a RINGAX station for applied loading and/or output.
- SECTAX - Defines a circumferential sector on a RINGAX station for distributed applied forces.
- FØRCE - Defines a concentrated force at a PØINTAX or load per length at a SECTAX location on the structure.
- FØRCEAX - Defines a generalized force directly on a specified harmonic of a RINGAX station.
- PRESAX - Defines a pressure load.
- TEMPAX - Defines a temperature distribution at a RINGAX point for thermal loading and temperature-dependent matrices.

The basic coordinate system for the solid of revolution elements is a cylindrical coordinate system (r , ϕ , z). The rotational degrees of freedom (components 4, 5 and 6) must be constrained.

The output quantities for the RINGAX points are the displacement coefficients for each harmonic. The output for the PØINTAX degrees of freedom are the sum of the harmonics giving the physical displacements at the point while output for SECTAX points are the average displacements over the circumferential sector. These quantities are available only in SØRT1 format.

The stress output for these elements is similar to that for the TRIARG and TRARPRG elements described above. However, since the stresses vary around the circumference, each element output includes the Fourier coefficients of stress for each harmonic followed by the stresses at the angular locations specified on the property card. Stresses are calculated at the centroid of the cross section on the TRIAAX element. Stresses are calculated at the four corners as well as at a fifth "grid point" on the TRAPAX element, which is located an average radius and average length from the four corner points.

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1.3.8 Scalar Elements

Scalar elements are connected between pairs of degrees of freedom (at either scalar or geometric grid points) or between one degree of freedom and ground. Scalar elements are available as springs, masses and viscous dampers. Scalar spring elements are useful for representing elastic properties that cannot be conveniently modeled with the usual metric structural elements. Scalar masses are useful for the selective representation of inertia properties, such as occurs when a concentrated mass is effectively isolated for motion in one direction only. The scalar damper is used to provide viscous damping between two selected degrees of freedom or between one degree of freedom and ground. It is possible, using only scalar elements and constraints, to construct a model for the linear behavior of any structure. However it is expected that these elements will be used only when the usual metric elements are not satisfactory. Scalar elements are useful for modeling part of a structure with its vibration modes or when trying to consider electrical or heat transfer properties as part of an overall structural analysis. The reader is referred to Sections 5.5 and 5.6 of the Theoretical Manual for further discussions on the use of scalar elements.

The most general definition of a scalar spring is given with a CELAS1 card. The associated properties are given on the PELAS card. The properties include the magnitude of the elastic spring, a damping coefficient, and a stress coefficient to be used in stress recovery. The CELAS2 defines a scalar spring without reference to a property card. The CELAS3 card defines a scalar spring that is connected only to scalar points and the properties are given on a PELAS card. The CELAS4 card defines a scalar spring that is connected only to scalar points and without reference to a property card. No damping coefficient or stress coefficient is available with the CELAS4 card.

Scalar elements may be connected to ground without the use of constraint cards. Grounded connections are indicated on the connection card by leaving the appropriate scalar identification number blank. Since the values for scalar elements are not functions of material properties, no references to such cards are needed.

The CDAMP1, CDAMP2, CDAMP3 and CDAMP4 cards define scalar dampers in a manner similar to the scalar spring definitions. The associated PDAMP card contains only a value for the scalar damper.

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1.3.9 Mass

Inertia properties are specified directly as mass elements attached to grid points and indirectly as the properties of matrix structural elements. In addition, dynamic analysis mass matrix coefficients may be specified that are directly referred to the global coordinate system. Some portions of the mass matrix are generated automatically while other portions are not. Mass data may be assembled according to two different kinds of relationships: lumped mass assumptions or coupled mass considerations. Additional information on treatment of inertia properties is given in Section 5.5 of the Theoretical Manual.

1.3.9.1 Lumped Mass

The partitions of the lumped mass matrix are explained in Section 5.5.3 of the Theoretical Manual, but to aid the user the form is repeated here in Equation 1.

$$M = \begin{bmatrix} \text{Scalar} & \begin{matrix} \text{1st} \\ \text{Moment} \end{matrix} \\ \begin{matrix} \text{1st} \\ \text{Moment} \end{matrix} & \begin{matrix} \text{2nd} \\ \text{Moment} \end{matrix} \end{bmatrix} = \begin{bmatrix} m_{ij} & N_{ij} \\ N_{ij}^T & I_{ij} \end{bmatrix} \quad (1)$$

The only portion of the lumped mass matrix that is automatically generated is the scalar partition. This implies that no first moment and second moment terms for the lumped mass matrix are automatically generated. In this context, automatic generation means the calculation of the mass from the structural elements that are connected to a given grid point, solely from the information provided on the element connection and property card. All of the metric structural elements (rods, bars, shear panels, twist panels, plates, and shell elements) may have uniformly distributed structural and nonstructural mass. Structural mass is calculated from material and geometric properties. The mass is assumed to be concentrated in the middle surface or along the neutral axis in the case of rods and bars, so that rotary inertia effects, including the torsional inertia of beams, are absent.

In the lumped mass method, the mass of an element is simply divided into equal portions and each portion is assigned to only one of the surrounding grid points. Thus, for uniform rods and bars, one-half of the mass is placed at each end; for uniform triangles, one-third of the mass is

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placed at each corner; quadrilaterals are treated as two pairs of overlapping triangles (see the Theoretical Manual Sections 5.3 and 5.8). The lumped mass matrix is independent of the elastic properties of elements. There are no other automatic routines for providing mass terms for the lumped mass approach.

1.3.9.2 Coupled Mass

In the coupled mass approach, properties of mass pertaining to a single structural element include off-diagonal coefficients that couple action at adjacent grid points. For further amplification of the techniques used in the coupled mass approach see Section 5.5.3 of the Theoretical Manual. To invoke the automatic generation of the coupled mass matrix, the parameter `CØUPMASS` is indicated on the PARAM card. If selected coupled mass properties are desired only for certain element types, this is obtained by a second parameter call specifying the element. For further details see the PARAM bulk data card. When using `CØUPMASS`, the nonzero terms are generated in off-diagonal positions of the mass matrix corresponding generally to nonzero terms of the stiffness matrix. This implies that a mass matrix generated by the coupled mass approach will generally have a density and topology equivalent to that of the stiffness matrix.

Off-diagonal mass terms may also be created during Guyan reduction when the `ØMIT` or `ASET` bulk data cards are used to condense the stiffness and mass matrices. Any mass associated with the omitted degrees of freedom will be redistributed to the remaining degrees of freedom forming a coupled mass matrix. The use of multipoint constraints (MPC cards) with mass terms on the dependent degrees of freedom produces a similar effect. The mass on the dependent coordinate will be transformed to the connected independent coordinates, thereby coupling them together. Mathematically, these operations and the element coupled mass formulations described above are closely related.

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1.3.9.3 Mass Input

In many cases it may be desired to add mass terms to the structure in addition to those generated by the structural elements. For instance, in a lumped mass formulation any additional masses involving rotational degrees of freedom must be independently calculated and input manually via bulk data cards.

The concentrated mass elements CØNM1 and CØNM2 may be used to add mass terms directly to a single grid point. The CØNM2 element is used to specify a rigid body with mass and inertia properties that is connected to a single grid point (offsets are allowed). The CONM1 element has a more general input format to allow directional mass terms.

The notation on the CONM1 card is explicit, that is, subscripting of each term spans the degree of freedom range from 1 through 6. On the CØNM2 card, double subscripting is used only for the second moment partition. Therefore, the correspondence for symbols between CØNM1 entries and CØNM2 entries for the second moment partition is as follows: I_{11} , I_{21} , I_{22} , I_{31} , I_{32} and I_{33} on the CØNM2 card (defined in Theoretical Manual section 5.5.2.2 by the integrals of Equations 13, 14 and 15) correspond to M_{44} , M_{54} , M_{55} , M_{64} , M_{65} and M_{66} on CØNM1 ($M_{54} = -I_{xy}$, $M_{64} = -I_{xz}$, $M_{65} = -I_{yz}$) with sign changes on the off-diagonal terms as shown in Equation 10 of the referenced section. The program multiplies each cross product of inertia term from CØNM2 user data by (-1) before assembling this data into the mass matrix, to make it correspond to the requirements of Equation 10.

An alternative to specifying mass information for the lumped mass method is to use the CMASSi and the PMASSi cards. This allows the option of treating mass as finite elements, one degree of freedom at a time. A particularly advantageous feature of the CMASSi card is the ability to couple mass terms between grid points and/or scalar points. When dynamic rigid formats are used, the direct matrix input (DMIG) may be used to supply grid point mass data. When mass information is entered via DMIG cards, it will remain dormant until activated by a call from Case Control via the M2PP card.

When a DMAP sequence is used or a rigid format is ALTERed, another form is available for presenting mass information via the DMI card. The DMI card is not recognized as a legitimate source of bulk data for the rigid formats, unless an ALTER is used.

In all cases a combination of mass input can be used. For instance, the translational inertias can be generated automatically by the element routines, while the first and second moment properties can be provided through CØNM2 cards. Some elements can be used to provide coupled mass properties through the CØUPMASS parameter, while other contributions to the same grid points can

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be made by direct matrix input through DMIG cards. The information from these several sources will be summed in the formation of the final mass matrix.

1.3.9.4 Output from the Grid Point Weight Generator

The Grid Point Weight Generator (GPWG) module computes the rigid body mass properties of an entire structure with respect to a user specified point and with respect to the center of mass.

Output from the module is requested by a PARAM card in the Bulk Data Deck which specifies from which grid point mass computations are to be referenced. Optionally, the absence of a specific grid point automatically causes the origin of the basic coordinate system to be utilized as a reference. The mass properties are initially defined in the basic coordinate system. Subsequently, the mass properties are transformed to principal mass axes and to principal inertia axes. The actual printout is composed of several elements. These are

1. Title MØ

This is the rigid body mass matrix of the entire structure in the basic coordinate system with respect to a reference point chosen by the analyst.

2. Title S

S is the transformation from the basic coordinate system to the set of principal axes for the 3 x 3 scalar mass partition of the 6 x 6 mass matrix. The principal axes for just the scalar partition are known as the principal mass axes.

3. Title X-C.G. Y-C.G. Z-C.G.

It is possible in NASTRAN to assemble a structural model having different values of mass in each coordinate direction at a grid point. This can arise for example assembling scalar mass components or from omitting some components by means of bar element pin flags. Consequently three distinct mass systems are assembled one in each of the three directions of the principal mass axes (the S system). This third tabulation has five columns. The first column lists the axis direction in the S coordinates. The second column lists the mass associated with the appropriate axis direction. The final three columns list the x, y, and z coordinate distances from the reference point to the center of mass for each of the three mass systems.

4. Title I(S)

This is the 3 x 3 mass moment of inertia partition with respect to the center of gravity referred to the principal mass axes (the S system). This is not necessarily a diagonal matrix because the determination of the S system does not involve second moments. The values of

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inertias at the center of gravity are found from the values at the reference point by employing the parallel axes rule.

5. Title I(Q)

The principal moments of inertia at the center of gravity are displayed in matrix form with reference to the Q system of axes. The Q system is obtained from an eigenvalue analysis of the I(s) matrix.

6. Title Q

Q is the coordinate transformation between the S axes and the Q axes.

1.3.9.5 Bulk Data Cards for Mass

A summary chart is given in Table 1 to help in the selection of the method of input for a given type of mass information. Descriptions of individual cards for the entering of mass information into the bulk data are listed here:

1. Element data from the combined sources of C(-), P(-), and MATi cards will automatically cause the translational mass (scalar) terms of the mass matrix to be generated, provided a density value and/or a nonstructural density factor is entered.
2. The MASSi cards define scalar masses. CMASSi cards define connections between a pair of degrees of freedom (at either scalar or geometric grid points) or between one degree of freedom and ground. Thus, $f_1 = m(x_1 - x_2)$ where x_2 may be absent. The CMASS1 cards ($i = 1$ through 4) are necessary whenever scalar points are used. PMASSi cards define mass property magnitudes. Other applications include selective representations of inertia properties, such as occur in shell theory where in-plane inertia forces are often ignored.
3. The CØNM2 card defines the properties of a solid body: m, its mass, x_1, x_2, x_3 , the three coordinates of its center of gravity offset with respect to the grid point, I_{11}, I_{22}, I_{33} , its three moments of inertia and I_{12}, I_{13}, I_{23} , and its three products of inertia, all with respect to any (selected) coordinate system. If a local cylindrical or a spherical coordinate system is chosen to define the mass properties, the offset distances of the mass c.g. from the grid point are measured along the axes(r,θ,z or ρ,θ,φ) defined at the grid point in that local system. Also note, that the mass properties of inertia are computed relative to a set axes at the mass c.g. which are parallel to those r,θ,z or ρ,θ,φ axes at that grid point. The CØNM2 element routine uses the parallel axis theorem to

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transform inertias with respect to the center of gravity to inertias with respect to the grid point. Section 5.5.2.1 of the Theoretical Manual describes how to treat the signs of cross products of inertia terms on CØNM2 cards.

4. The CØNM1 card defines a 6 x 6 matrix of mass coefficients at a geometric grid point in any selected coordinate system. Since the only restrictions are that the matrix be real and symmetric, there are 21 possible independent coefficients. The CØNM1 card therefore permits somewhat more general inertia relationships than those of a solid body which has only 10 independent inertia properties. This should be remembered in applications requiring unique centers of gravity, such as in the calculation of centrifugal forces. See Section 5.5.2.5 of the Theoretical Manual for a discussion of inertia properties resulting from CØNM1 card input.
5. The DMIG (or DMIGAX for axisymmetric structures) card accomodates matrix entries by grid point and component. This is a general card that can be used for mass, stiffness, or damping matrices. It becomes particularized to mass when the name given to the matrix is called by an M2PP card in Case Control. Data defined by this card will be recognized as admissible only when used with dynamic rigid formats 7 through 12.
6. The DMI card is used to assign values according to row-column positions in a matrix. This is a general card for any kind of matrix which becomes particularized to mass when the name given to the matrix is called from a DMAP statement. Data defined by this card will be recognized as admissible only when used in a DMAP sequence or in an ALTER to a rigid format.
7. The COUPMASS entry on the PARAM card will activate the "consistent" mass matrix algorithms in the element routines which generate mass coupling properties between grid points. There are three options available to regulate whether the coupling properties are generated for all or some types of elements (see PARAM bulk data card). A set of entries for a second PARAM card of the form CP(element name) are available for use in connection with CØUPMASS for selecting the element types for which coupling terms will be computed.
8. The ØMIT (or ØMIT1, or ØMITAX for axisymmetric structures, or ASET for obverse operations) card will cause the initially-generated mass matrix to be condensed from the omitted degrees of freedom to the remaining degrees of freedom. The condensing process generally produces a mass term in every matrix position in which there is a nonzero stiffness term in the corresponding reduced stiffness matrix.

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9. The GRDPNT entry on the PARAM card will activate the Grid Point Weight Generator (GPWG) module previously discussed. It will treat the mass properties of the entire structure as though the structure were rigid and it will determine the translational (scalar) mass properties, the first and second moment properties of the rigid body structure and the center of gravity distances with respect to the user specified reference grid points. It also computes the 6 x 6 matrix of mass properties with respect to the center of mass and the orientation of the principal mass axes.

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Table 1. Bulk Data Card Choices for Mass Properties Versus Method of Mass Representation.

Representation Method Mass Property	Lumped			Coupled		Grid Point Weight Generator (Total Structure)
	Automatic	Manual		Automatic	Manual	
		All R.F.'s	R.F.'s 7, 8, 9	DMAP or R.F. ALTER		
Translational Mass (Scalar)	Element Routines C (element) + P (element) + MATi for structural and nonstructural contributions	MASSi CØNM1 CØNM2	MASSi CØNM1 CØNM2 DMIG DMIGAX	DMI	PARAM CØUPMASS + PARAM CP (element) ØMIT ØMIT1 ØMITAX ASET	↕ PARAM GRDPNT ↕
First Moment		MASSi CØNM1 CØNM2	MASSi CØNM1 CØNM2 DMIG DMIGAX	DMI	DMIG DMIGAX	↕ PARAM GRDPNT ↕
Second Moment		MASSi CØNM1 CØNM2	MASSi CØNM1 CØNM2 DMIG DMIGAX	DMI		
All Order Moments and Off-Diagonal Properties Between Grid Points					PARAM CØUPMASS + PARAM CP (element) ØMIT ØMIT1 ØMITAX ASET	DMIG DMIGAX

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1.3.10 Solid Polyhedron Elements

Three types of solid polyhedron elements are provided for the general solid structures (see Section 1.3.7 for axisymmetric structures with axisymmetric loads). These elements (see Figure 12) are a tetrahedron, a wedge and a hexahedron. The theory is given in Section 5.12 of the Theoretical Manual. These elements can be used with all other NASTRAN elements, except the axisymmetric elements. Connections are made only to displacement degrees of freedom at the grid points.

The elements are defined by CTETRA, CWEDGE, CHEXA1, and CHEXA2 connection cards. The user should specify grid locations such that the quadrilateral faces are nearly planar. No special element coordinate system is required. The only properties required are material properties, thus no PID card is referenced; direct reference is made to a MID card. For thermal stress problems, the temperature is assumed to be the average of the connected grid points. Differential stiffness, buckling, and piecewise linear analyses have not been implemented.

The output stresses are given in the basic coordinate system. In addition to the six normal and shear stresses, output also includes the pressure

$$p_0 = -\frac{1}{3} (\sigma_x + \sigma_y + \sigma_z)$$

and the octahedral stress

$$\sigma_0 = \frac{1}{3} \left[(\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6\tau_{yz}^2 + 6\tau_{zx}^2 + 6\tau_{xy}^2 \right]^{1/2}$$

The stresses in the tetrahedra are constant. The stresses in the wedge and the hexahedron are obtained as the weighted average of the stresses in the subtetrahedra. The weighting factor for each tetrahedra is proportional to its volume.

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1.3.11 Isoparametric Solid Hexahedron Elements

Three types of isoparametric solid hexahedron elements are provided for general solid structures. These elements (see Figure 13) are a linear, a quadratic, and a cubic isoparametric hexahedron. The theory is given in Section 5.13 of the Theoretical Manual. These elements can be used with all other NASTRAN elements, except the axisymmetric elements. Connections are made only to the translational degrees of freedom at the grid points. The elements are defined by CIHXL, CIHXL2, and CIHXL3 connection cards. All three of these cards reference the PIHXL property card.

The isoparametric solid hexahedron elements allow the user to accurately define a structure with fewer elements and grid points than might otherwise be necessary with simple constant strain solid elements. The linear element generally gives best results for problems involving mostly shear deformations, and the higher order elements give good results for problems involving both shearing and bending deformations. Only a coupled mass matrix is generated to retain the inherent accuracy of the elements. Temperature, temperature-dependent material properties, displacements, and stresses may vary through the volume of the elements. The values at interior points of the element are interpolated using the isoparametric shape function. For best results, the applied grid point temperatures should not have more than a "gentle" quadratic variation in each of the three dimensions of the element. If the element has non-uniform applied temperatures, or if it is not a rectangular parallelepiped, three or more integration points should be specified on the PIHXL card. Severely distorted element shapes should be avoided.

Stiffness, mass, differential stiffness, structural damping, conductance, and capacitance matrices may be generated with these elements. Piecewise linear analysis has not been implemented.

The output stresses are given in the basic coordinate system. The stresses are assumed to vary through the element. Therefore, stresses are computed at the center and at each corner grid point of these elements. For the quadratic and cubic elements, they are also computed at the mid-point of each edge of the element. In addition to the six normal and shear stresses, output also includes the principal stresses (S_x , S_y , and S_z), the direction cosines of the principal planes, the mean stress

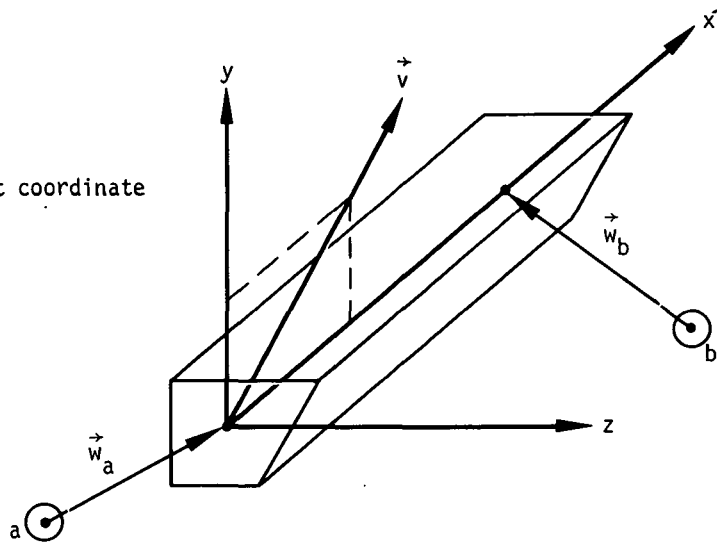
$$\sigma_n = -\frac{1}{3} (\sigma_x + \sigma_y + \sigma_z) ,$$

and the octahedral shear stress

$$\sigma_o = \left\{ \frac{1}{3} [(S_x + \sigma_n)^2 + (S_y + \sigma_n)^2 + (S_z + \sigma_n)^2] \right\}^{1/2} .$$

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(a) Element coordinate system



(b) Element forces

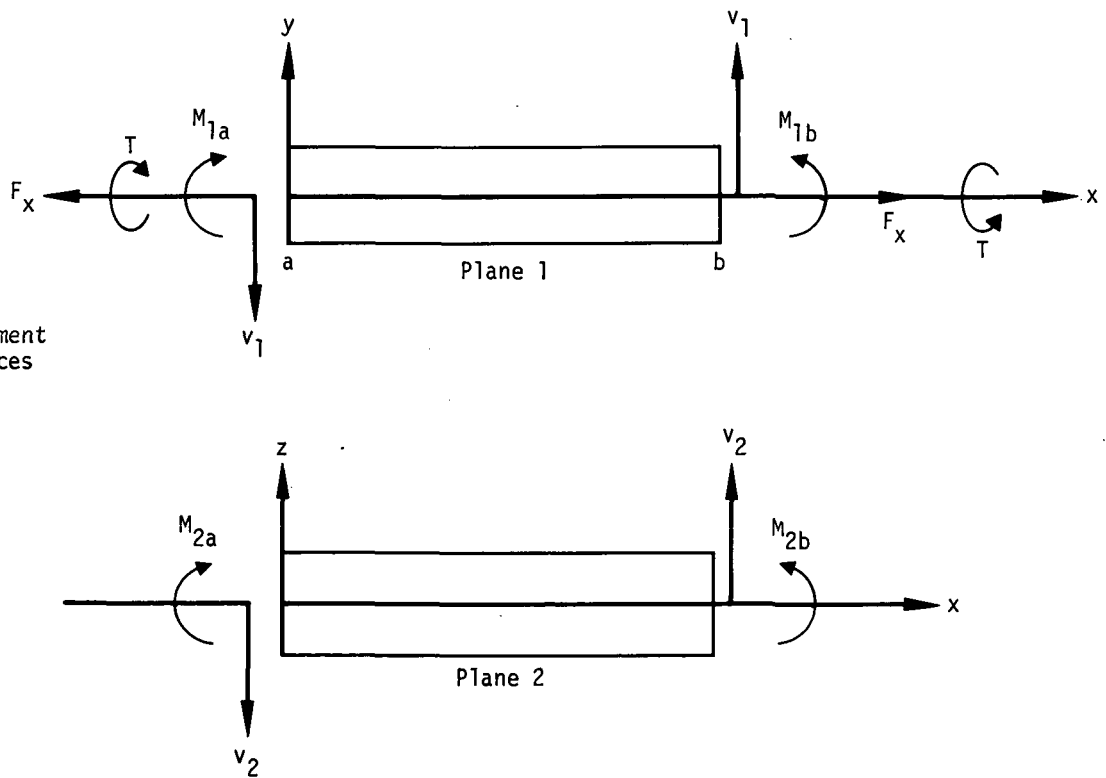


Figure 1. Bar element coordinate system and element forces.

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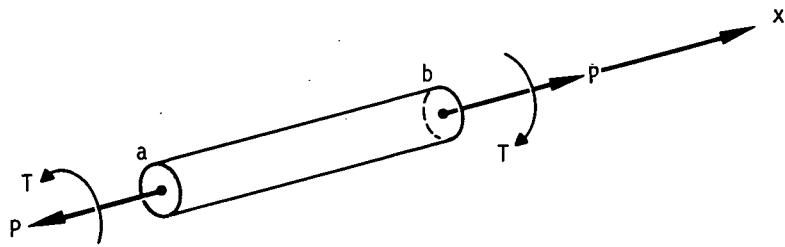
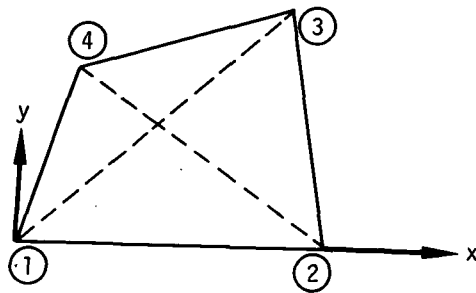
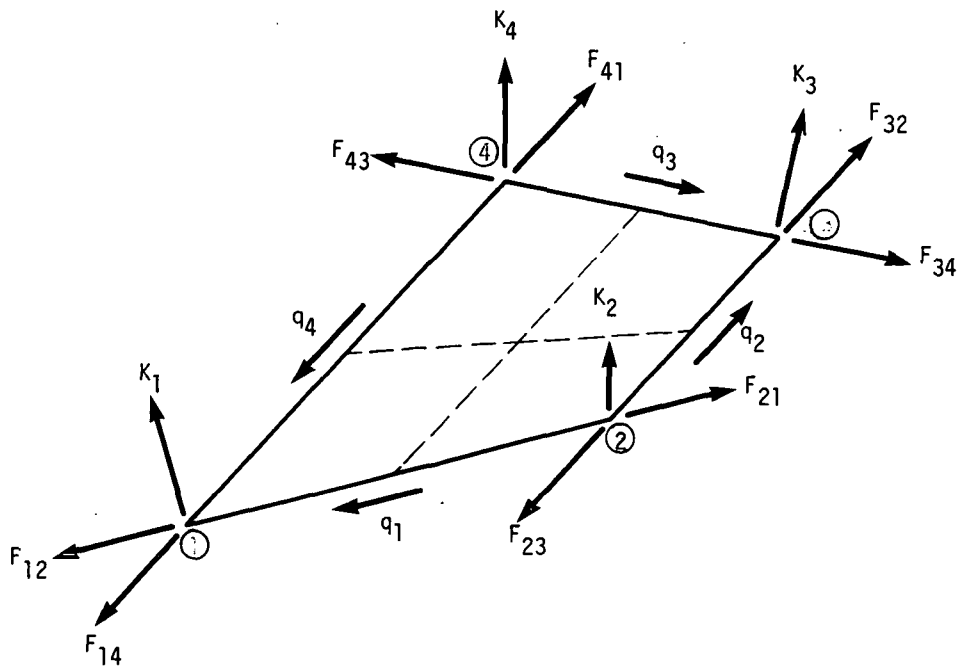


Figure 2. Rod element coordinate system and element forces.

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(a) Coordinate System.



(b) Corner forces and shear flows.

Figure 3. Coordinate system and element forces for shear panel and CQDMEM2 elements.

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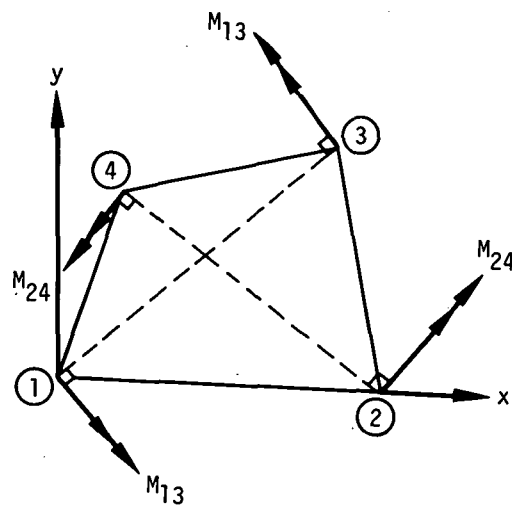
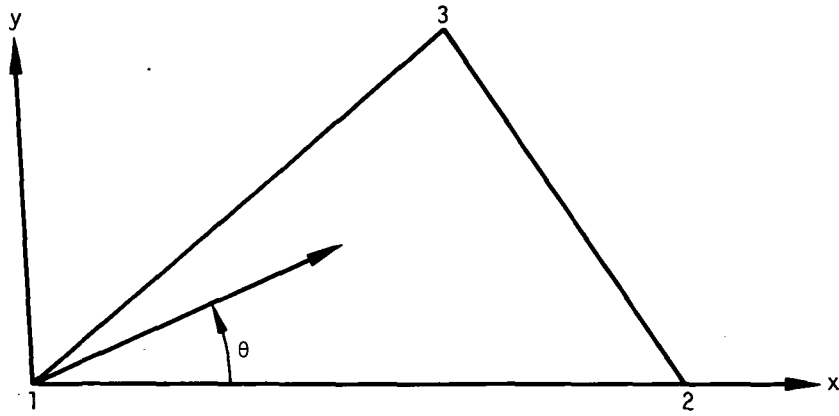
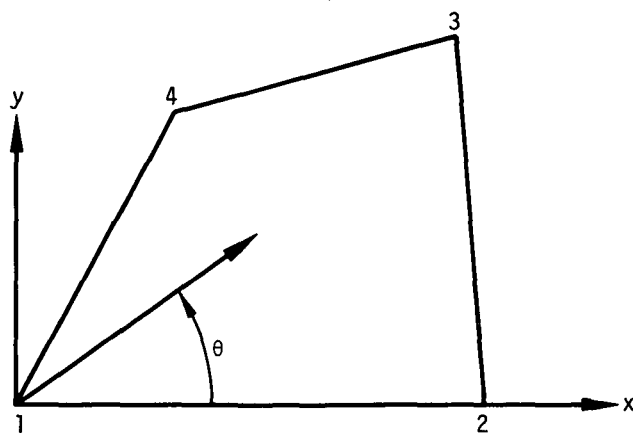


Figure 4. Twist panel coordinate system and element forces.

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(a)



(b)

Figure 5. Plate element coordinate systems.

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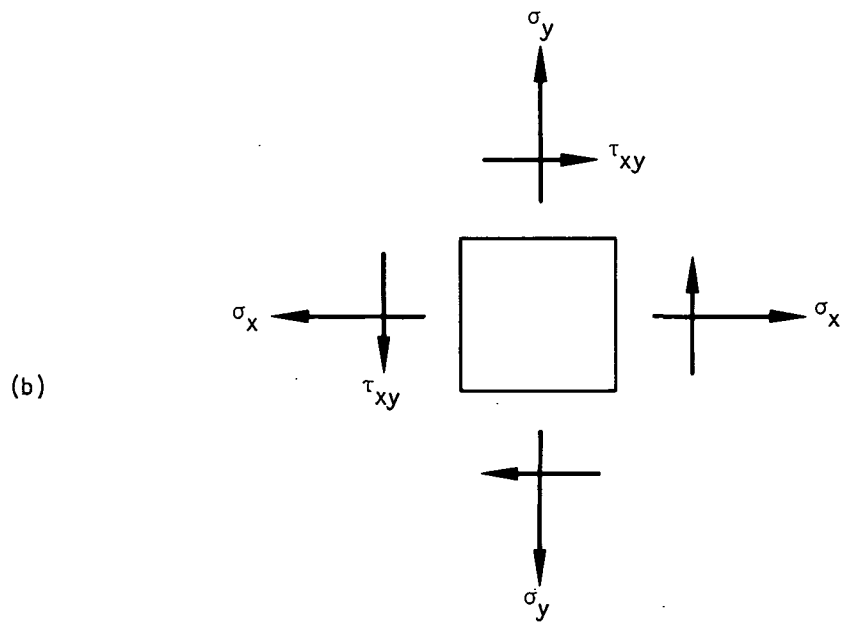
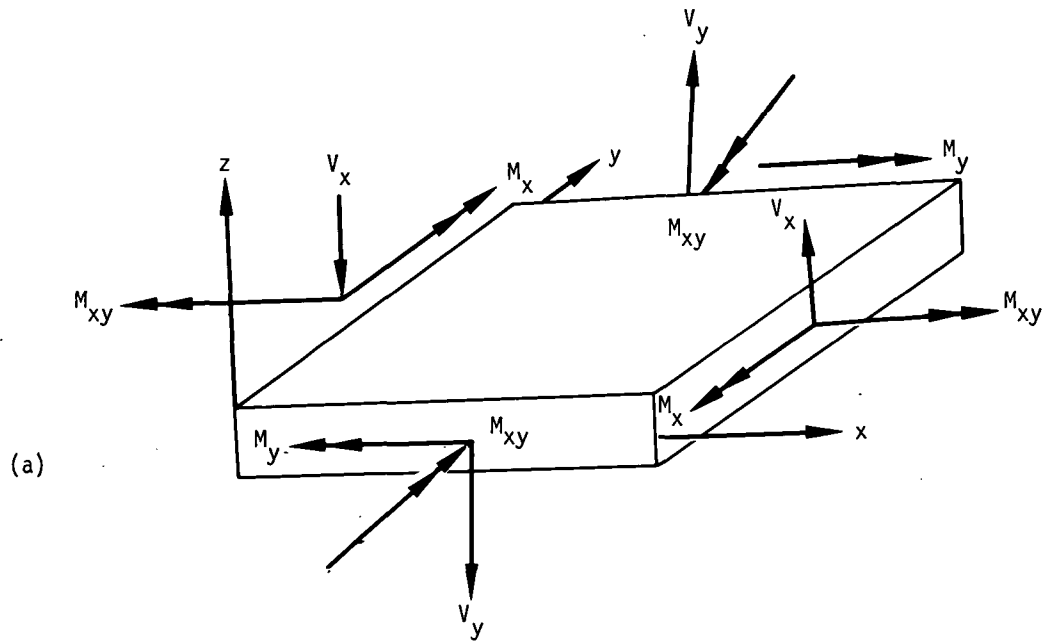


Figure 6. Forces and stresses in plate elements.

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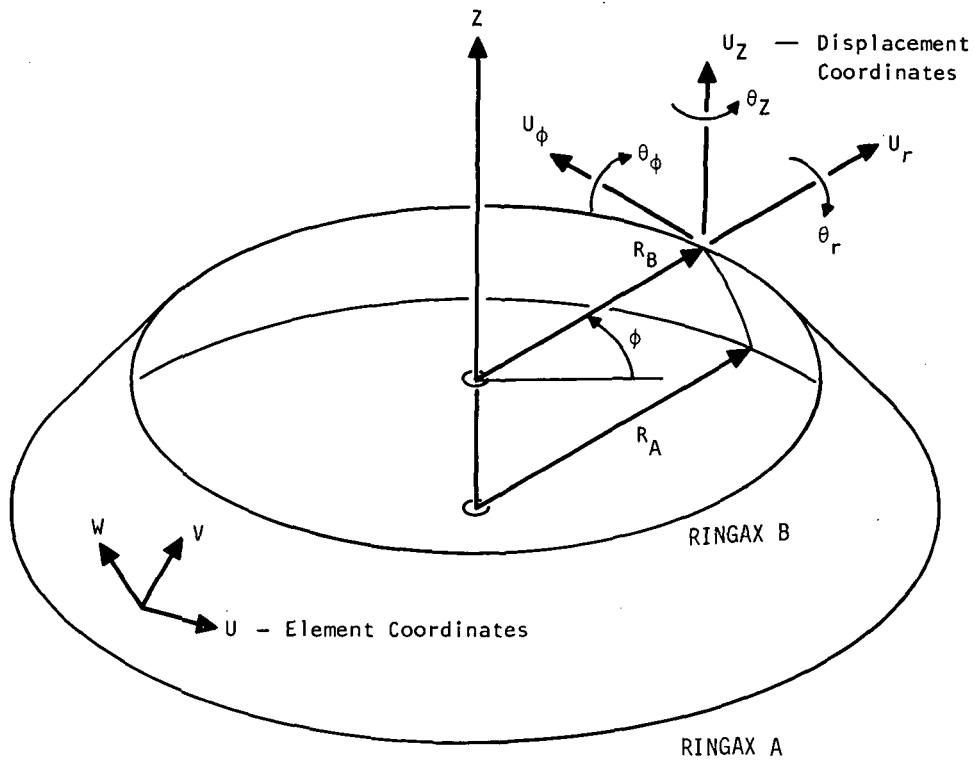


Figure 7. Geometry for conical shell element.

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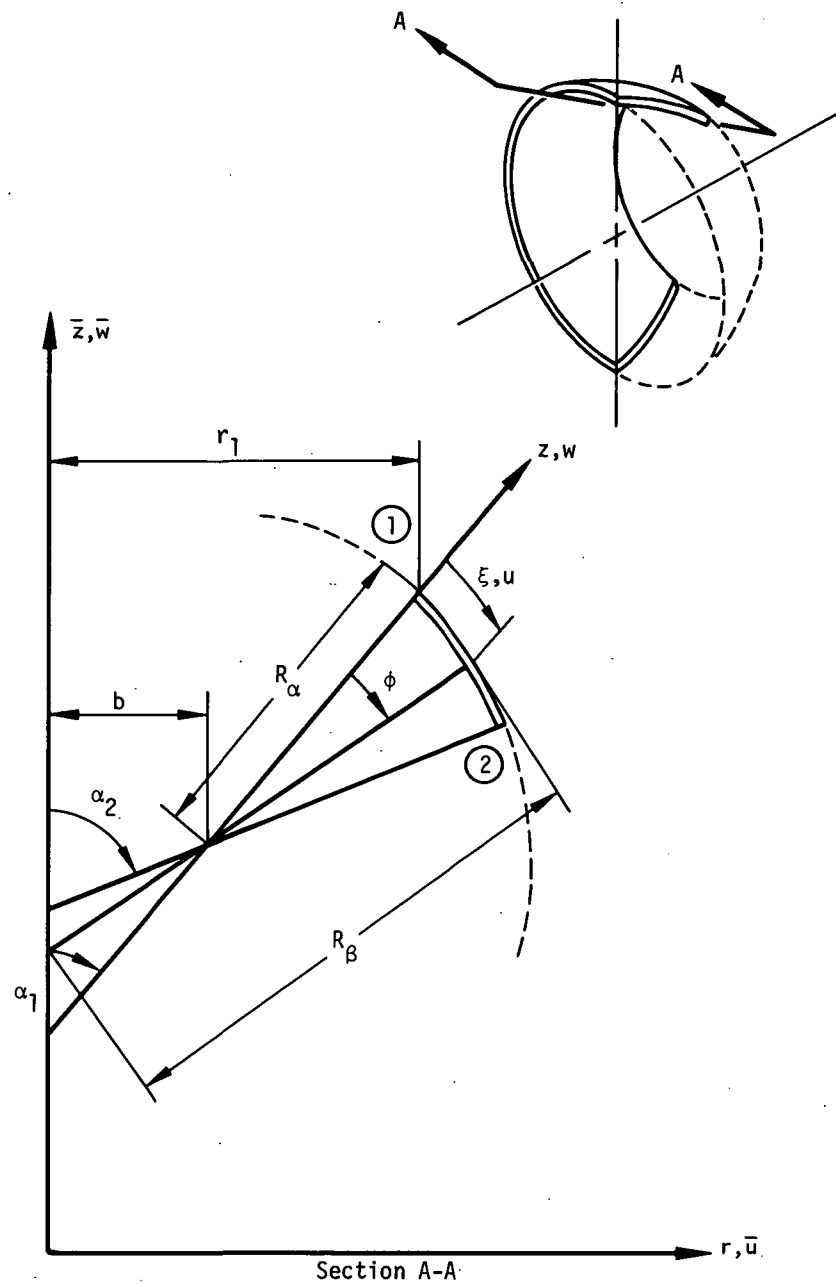


Figure 8. Toroidal ring element coordinate system.

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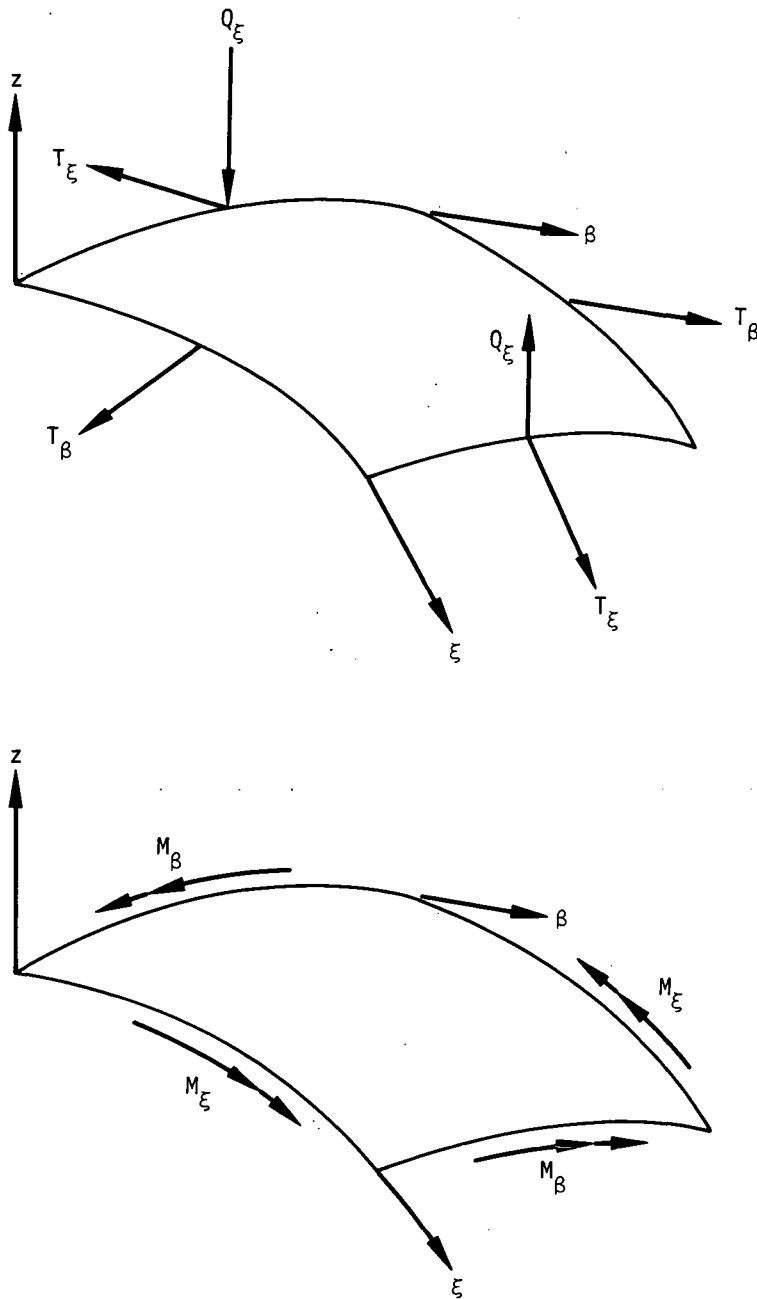


Figure 9. Stresses for toroidal element.

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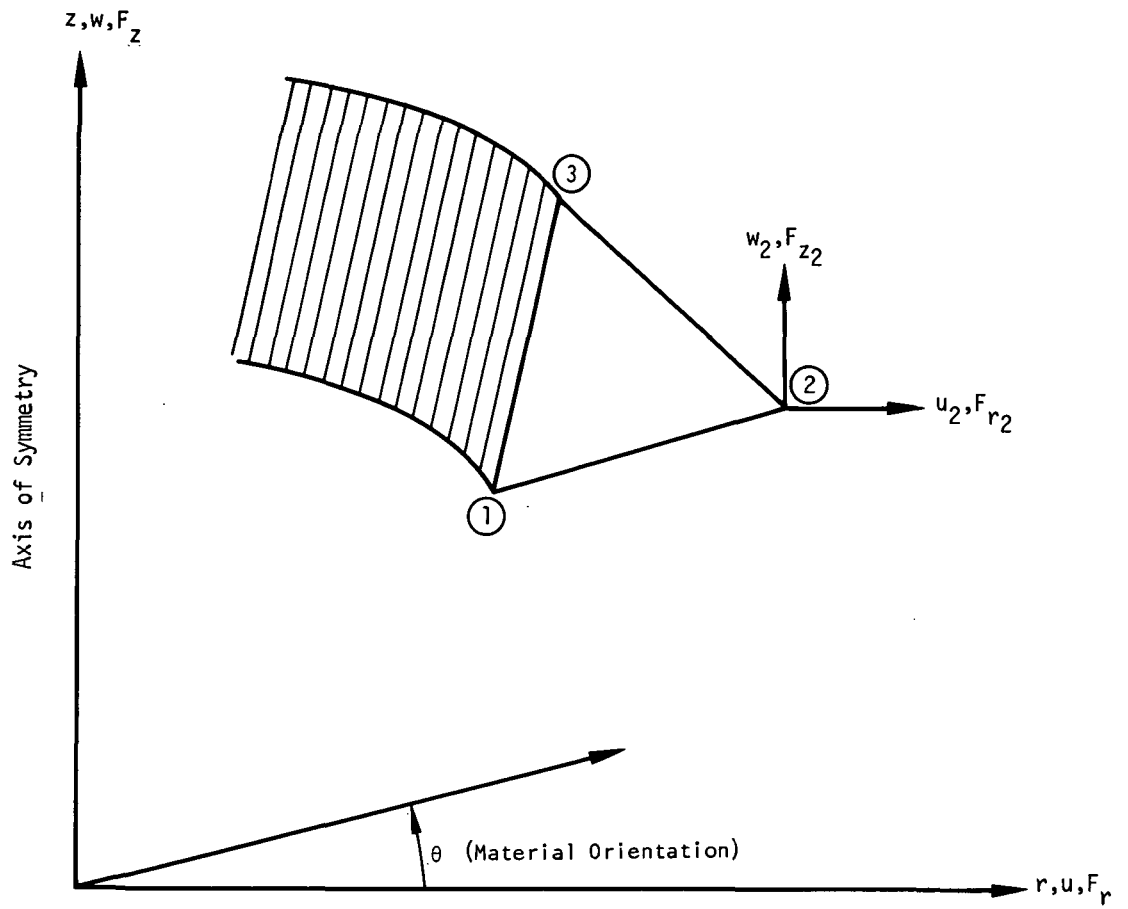


Figure 10. Triangular ring element coordinate system.

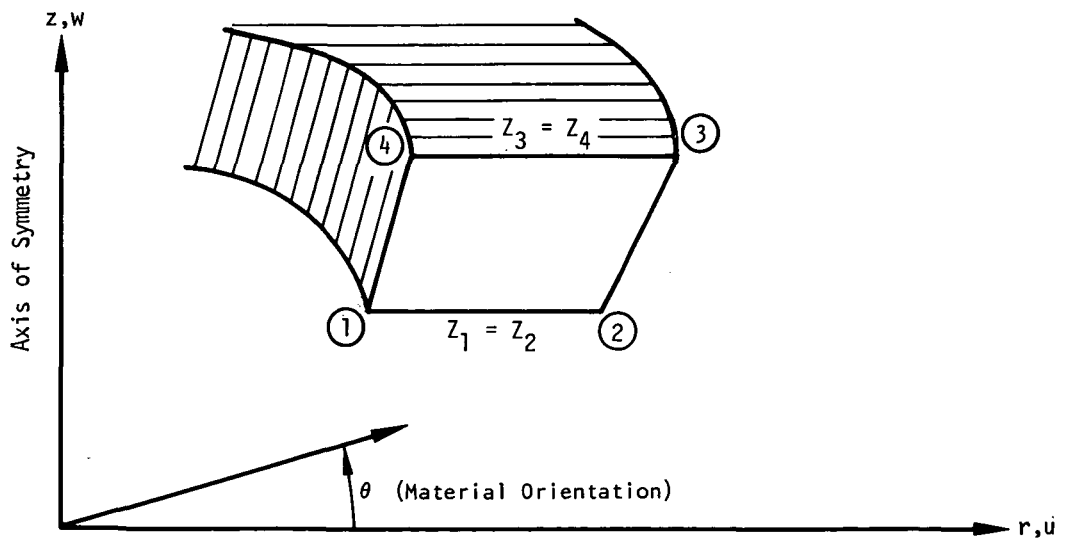
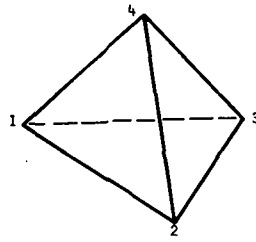
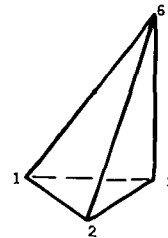
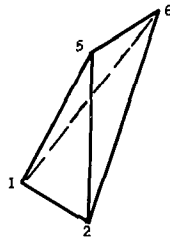
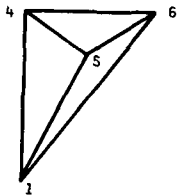
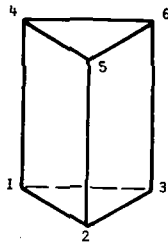


Figure 11. Trapezoidal ring element coordinate system.

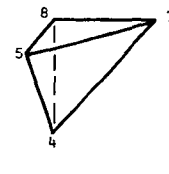
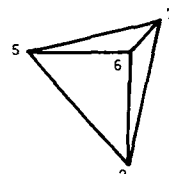
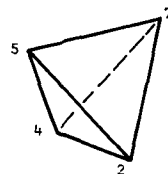
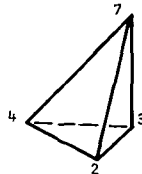
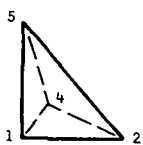
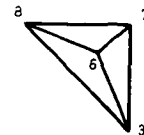
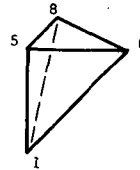
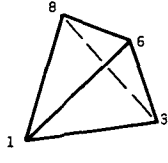
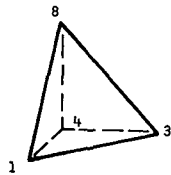
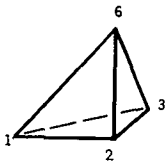
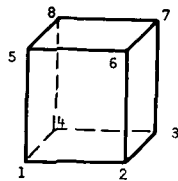
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(a) Tetrahedron.



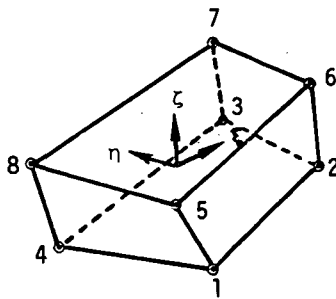
(b) Wedge and One of its Six Decompositions.



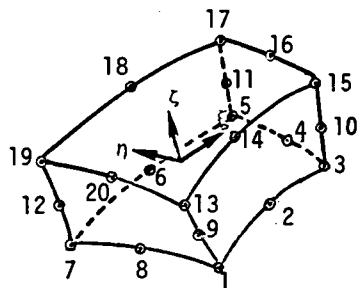
(c) Hexahedron and its Two Decompositions.

Figure 12. - Polyhedron elements and their subtetrahedra.

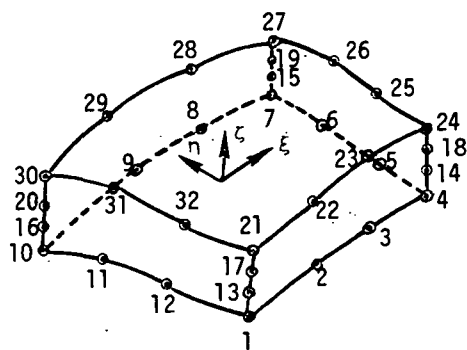
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(a) Linear



(b) Quadratic



(c) Cubic

Figure 13. Isoparametric solid hexahedron elements

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1.4 CONSTRAINTS AND PARTITIONING

Structural matrices are initially assembled in terms of all structural grid points, which excludes only the extra scalar points introduced for dynamic analysis. These matrices are generated with six degrees of freedom for each geometric grid point and a single degree of freedom for each scalar point. Various constraints are applied to these matrices in order to remove undesired singularities, provide boundary conditions, define rigid elements, and provide other desired characteristics for the structural model.

There are two basic kinds of constraints. Single-point constraints are used to constrain a degree of freedom to zero or to a prescribed value, and multipoint constraints are used to constrain a degree of freedom to be equal to a linear combination of the values of other degrees of freedom. The following four types of bulk data cards are provided for the definition of constraints:

1. Single-point constraint cards
2. Multipoint constraint cards
3. Cards to define reaction points on free bodies
4. Cards to define the omitted coordinates in matrix partitioning

The latter type does not produce constraint forces in static analysis.

1.4.1 Single-Point Constraints

A single-point constraint applies a fixed value to a translational or rotational component at a geometric grid point or to a scalar point. One of the most common uses of single-point constraints is to specify the boundary conditions of a structural model by fixing the appropriate degrees of freedom. Multiple sets of single-point constraints can be provided in the Bulk Data Deck, with selections made at execution time by using the subcase structure in the Case Control Deck as explained in Section 2.3.3. This procedure is particularly useful in the solution of problems having one or more planes of symmetry.

The elements connected to a grid point may not provide resistance to motion in certain directions, causing the stiffness matrix to be singular. Single-point constraints are used to remove these degrees of freedom from the stiffness matrix. A typical example is a planar structure composed of membrane and extensional elements. The translations normal to the plane and all three rotational degrees of freedom must be constrained since the corresponding stiffness matrix

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terms are all zero. If a grid point has a direction of zero stiffness, the single-point constraint need not be exactly in that direction, but only needs to have a component in that direction. This allows the use of single-point constraints for the removal of such singularities regardless of the orientation of the global coordinate system. Although the displacements will depend on the direction of the constraint, the internal forces will be unaffected.

One of the tasks performed by the Structural Matrix Assembler (Section 4.27 of the Programmer's Manual) is to examine the stiffness matrix for singularities at the grid point level. Singularities remaining at this level, following the application of the single-point constraints, are listed in the Grid Point Singularity Table (GPST). This table is automatically printed following the comparison of the possible singularities tabulated by the Structural Matrix Assembler with the single-point constraints and the dependent coordinates of the multipoint constraint equations provided by the user. The GPST contains all possible combinations of single-point constraints, in the global coordinate system, that can be used to remove the singularities. These remaining singularities are treated only as warnings, because it cannot be determined at the grid point level whether or not the singularities are removed by other means, such as general elements or multipoint constraints in which these singularities are associated with independent coordinates.

Single-point constraints are defined on SPC, SPC1, SPCADD and SPCAX cards. The SPC card is the most general way of specifying single-point constraints. The SPC1 card is a less general card that is more convenient when a number of grid points have the same components constrained to a zero displacement. The SPCADD card defines a union of single-point constraint sets specified with SPC or SPC1 cards. The SPCAX card is used only for specifying single-point constraints in problems using conical shell elements.

Single-point constraints can also be defined on the GRID card. In this case, however, the constraints are part of the model and modifications cannot be made at the subcase level. Also, only zero displacements can be specified on the GRID card.

1.4.2 Multipoint Constraints

Each multipoint constraint is described by a single equation that specifies a linear relationship for two or more degrees of freedom. Multiple sets of multipoint constraints can be provided in the Bulk Data Deck, with selections made at execution time by using the subcase structure in the Case Control Deck as explained in Section 2.3.3. Multipoint constraints are

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discussed in Sections 3.5.1 and 5.4 of the Theoretical Manual.

Multipoint constraints are defined on MPC, MPCADD and MPCAX cards. The MPC card is the basic card for defining multipoint constraints. The first coordinate mentioned on the card is taken as the dependent degree of freedom, i.e. that degree of freedom that is removed from the equations of motion. Dependent degrees of freedom may appear as independent terms in other equations of the set, however, they may appear as dependent terms in only a single equation. The MPCADD card defines a union of multipoint constraint sets specified with MPC cards. The MPCAX card is used only for specifying multipoint constraints in problems using conical shell elements. Some uses of multipoint constraints are:

1. To enforce zero motion in directions other than those corresponding with components of the global coordinate system. In this case, the multipoint constraint will involve only the degrees of freedom at a single grid point. The constraint equation relates the displacement in the direction of zero motion to the displacement components in the global system at the grid point.
2. To describe rigid elements and mechanisms such as levers, pulleys and gear trains. In this application, the degrees of freedom associated with the rigid element that are in excess of those needed to describe rigid body motion are eliminated with multipoint constraint equations. Treatment of very stiff members as being rigid elements eliminates the ill-conditioning associated with their treatment as ordinary elastic elements.
3. To be used with scalar elements to generate nonstandard structural elements and other special effects.
4. To describe parts of a structure by local vibration modes. This application is treated in section 14.1 of the Theoretical Manual. The general idea is that the matrix of local eigenvectors represents a set of constraints relating physical coordinates to modal coordinates.

At present, the user provides the coefficients in the multipoint constraint equations.

1.4.3 Free Body Supports

In the following discussion, a free body is defined as a structure that is capable of motion without internal stress, i.e. it has one or more rigid body degrees of freedom. The stiffness matrix for a free body is singular with the defect equal to the number of stress-free, or rigid

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body modes. A solid three-dimensional body has up to six rigid body modes. Linkages and mechanisms can have a greater number. No restriction is placed in the program on the number of stress-free modes, in order to permit the analysis of mechanisms.

Free-body supports are defined with a SUPØRT card. In the case of problems using conical shell elements, the SUPAX card is used. In either case, only a single set can be specified, and if such cards appear in the Bulk Data Deck, they are automatically used in the solution. Free-body supports must be defined in the global coordinate system.

In static analysis by the displacement method, the rigid body modes must be restrained in order to remove the singularity of the stiffness matrix. The required constraints may be supplied with single-point constraints, multipoint constraints, or free-body supports. If free-body supports are used, the rigid body characteristics will be calculated and a check will be made on the sufficiency of the supports. Such a check is obtained by calculating the rigid body error ratio as defined in the Rigid Body Matrix Generator operation in Section 3.2.2. This error ratio is automatically printed following the execution of the Rigid Body Matrix Generator. The error ratio should be zero, but may be nonzero for any of the following reasons:

1. Round-off error accumulation
2. Insufficient free-body supports have been provided
3. Redundant free-body supports have been provided

The redundancy of the supports may be caused by improper use of the free-body supports themselves, or by the presence of single-point or multipoint constraints that constrain the rigid body motions.

Static analysis with inertia relief is necessarily made on a model having at least one rigid body motion. Such rigid body motion must be constrained by the use of free-body supports. These supported degrees of freedom define a reference system, and the elastic displacements are calculated relative to the motion of the support points. The element stresses and forces will be independent of any valid set of supports.

Rigid body vibration modes are calculated by a separate procedure provided that a set of free-body supports are supplied by the user. This is done to improve efficiency and, in some cases, reliability. The determinant method, for example, has difficulty extracting zero frequency roots of high multiplicity, whereas the alternate procedure of extracting rigid body modes is both efficient and reliable. If the user does not specify free-body supports (or he specifies

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an insufficient number of them) the (remaining) rigid body modes will be calculated by the method selected for the finite frequency modes, provided zero frequency is included in the range of interest. If the user does not provide free-body supports, and if zero frequency is not included in the range of interest, the rigid body modes will not be calculated.

Free-body supports must be specified if the mode acceleration method of solution improvement is used for dynamics problems having rigid body degrees of freedom (see Section 9.4 of the Theoretical Manual). This solution improvement technique involves a static solution, and although the dynamic solution can be made on a free-body, the static solution cannot be performed without removing the singularities in the stiffness matrix associated with the rigid body motions.

1.4.4 Partitioning

A two-way partitioning scheme is provided as an optional feature for the NASTRAN model. The partitions are defined by listing the degrees of freedom for one of the partitions on the OMIT card. These degrees of freedom are referred to as the omitted set. The remaining degrees of freedom are referred to as the analysis set. The OMIT1 Card is easier to use if a large number of grid points have the same degrees of freedom in the omitted set. The ASET or ASET1 cards can be used to place degrees of freedom in the analysis set with the remaining degrees of freedom being placed in the omitted set. This is easier if the omitted set is large. In the case of problems using conical shell elements, the OMITAX card is used.

Partitioning can be used to improve the efficiency in the solution of ordinary statics problems where the bandwidth of the unpartitioned stiffness matrix is large enough to cause excessive use of secondary storage devices during the triangular decomposition of the stiffness matrix. In this application, the analysis set should be relatively small and should be selected so that the omitted set will consist of uncoupled partitions, each having a bandwidth of approximately the same size and smaller than the original matrix. The omitted set might be thought of as consisting of several substructures which are coupled to the analysis set.

Matrix partitioning also improves efficiency when solving a number of similar cases with stiffness changes in local regions of the structure. In this application, the omitted set is relatively large, and should be selected so that the structural elements that will be changed are connected only to points in the analysis set. The stiffness matrix for the omitted set is then unaffected by the structural changes, and only the smaller stiffness matrix for the analysis set

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need be decomposed for each case. In order to avoid repeating the decomposition of the stiffness matrix for the omitted set, the alter feature must be used to replace the functional module SMP1 with SMP2. The alter feature is described in section 2.2, and a similar use of SMP2 occurs near the end of the DMAP sequence used in the rigid format for Static Analysis with Differential Stiffness.

One of the more important applications of partitioning is the Guyan Reduction, described in Section 3.5.4 of the Theoretical Manual. This technique is a means for reducing the number of degrees of freedom used in dynamic analysis with minimum loss of accuracy. Its basis is that many fewer grid points are needed to describe the inertia of a structure than are needed to describe its elasticity with comparable accuracy. The error in the approximation is small provided that the set of displacements used for dynamic analysis is judiciously chosen. Its members should be uniformly dispersed throughout the structure and all large mass items should be connected to grid points that are members of the analysis set.

The user is cautioned to consider the fact that the matrix operations associated with this partitioning procedure tend to create nonzero terms and to fill what were previously very sparse matrices. The partitioning option is most effectively used if the members of the omitted set are either a very large fraction or a very small fraction of the total set. In most of the applications the omitted set is a large fraction of the total and the matrices used for analysis, while small, are usually full. If the analysis set is not a small fraction of the total, a solution using the larger, but sparser matrices, may well be more efficient. The partitioning option can also be used to make modest reductions in the order of the problem by placing a few scattered grid points in the omitted set. If the points in the omitted set are uncoupled, the sparseness in the matrices will be well preserved.

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1.5 APPLIED LOADS

1.5.1 Static Loads

In NASTRAN, static loads are applied to geometric and scalar grid points in a variety of ways, including:

1. Loads applied directly to grid points.
2. Pressure on surfaces.
3. Gravity loads (internally generated).
4. Centrifugal forces due to steady rotation.
5. Equivalent loads resulting from thermal expansion
6. Equivalent loads resulting from enforced deformations of structural elements.
7. Equivalent loads resulting from enforced displacements of grid points.

Additional information on static loads is given in Section 3.6 of the Theoretical Manual. Any number of load sets can be defined in the Bulk Data Deck. However, only those sets selected in the Case Control Deck, as described in Section 2.3, will be used in the problem solution. The manner of selecting each type of load is specified on the associated bulk data card description in Section 2.4.

The FØRCE card is used to define a static load applied to a geometric grid point in terms of components defined by a local coordinate system. The orientation of the load components depends on the type of local coordinate system used to define the load. The directions of the load components are the same as those indicated on Figure 1 of Section 1.2 for displacement components. The FØRCE1 card is used if the direction is determined by a vector connecting two grid points, and a FØRCE2 card is used if the direction is specified by the cross product of two such vectors. The MØMENT, MØMENT1 and MØMENT2 cards are used in a similar fashion to define the application of a concentrated moment at a geometric grid point. The SLØAD card is used to define a load at a scalar point. In this case, only the magnitude is specified, as only one component of motion exists at a scalar point.

The FØRCEAX and MØMAX cards are used to define the loading of specified harmonics on rings of conical shell elements. FØRCE and MØMENT cards may be used to apply concentrated loads or moments to conical shell elements, providing that such points have been defined with a PØINTAX card.

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Pressure loads on triangular and quadrilateral elements are defined with a PLØAD2 card. The positive direction of the loading is determined by the order of the grid points on the element connection card, using the right hand rule. The magnitude and direction of the load is automatically computed from the value of the pressure and the coordinates of the connected grid points. The load is applied to the connected grid points. The PLØAD card is used in a similar fashion to define the loading of any three or four grid points regardless of whether they are connected with two-dimensional elements. The PRESAX card is used to define a pressure loading on a conical shell element.

Pressure loads on the isoparametric solid elements are defined with the PLØAD3 card. The pressure is defined positive outward from the element. The magnitude and direction of the equivalent grid point forces are automatically computed using the isoparametric shape functions of the element to which the load has been applied.

The GRAV card is used to specify a gravity load by providing the components of the gravity vector in any defined coordinate system. The gravity load is obtained from the gravity vector and the mass matrix assembled by the Structural Matrix Assembler (see Section 4.28 of the Programmer's Manual). The gravitational acceleration is not calculated at scalar points. The user is required to introduce gravity loads at scalar points directly.

The RFØRCE card is used to define a static loading condition due to a centrifugal force field. A centrifugal force load is specified by the designation of a grid point that lies on the axis of rotation and by the components of rotational velocity in any defined coordinate system. In the calculation of the centrifugal force, the mass matrix is regarded as pertaining to a set of distinct rigid bodies connected to grid points. Deviations from this viewpoint, such as the use of scalar points or the use of mass coupling between grid points, can result in errors.

Temperatures may be specified for selected elements. The temperatures for a RØD, BAR, CØNRØD or TUBE element are specified on the TEMPRB data card. This card specifies the average temperature on both ends and, in the case of the BAR element, is used to define temperature gradients over the cross section. Temperatures for two dimensional plate and membrane elements are specified on a TEMPP1, TEMPP2, or TEMPP3 data card. The user defined average temperature over the volume is used to produce in-plane loads and stresses. Thermal gradients over the depth of the bending elements, or the resulting moments, may be used to produce bending loads and stresses.

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If no thermal element data is given for an element, the temperatures of the connected grid points given on the TEMP, TEMPD or TEMPAX cards are simply averaged to produce an average temperature for the element. The thermal expansion coefficients are defined on the material definition cards. Regardless of the type of thermal data, if the material coefficients for an element are temperature-dependent by use of the MATTi card, they are always calculated from the "average" temperature of the element. The mere presence of a thermal field does not imply the application of a thermal load. A thermal load will not be applied unless the user makes a specific request in the Case Control Deck.

Enforced axial deformations can be applied to rod and bar elements. They are useful in the simulation of misfit and misalignment in engineering structures. As in the case of thermal expansion, the equivalent loads are calculated by separate subroutines for each type of structural element, and are applied to the connected grid points. The magnitude of the axial deformation is specified on a DEFØRM card.

Zero enforced displacements may be specified on GRID, SPC or SPC1 cards. Zero displacements which result in nonzero forces of constraint are usually specified on SPC or SPC1 cards. If GRID cards are used, the constraints become part of the structural model and modifications cannot be made at the subcase level.

Nonzero enforced displacements may be specified on SPC or SPCD cards. The SPC card specifies both the component to be constrained and the magnitude of the enforced displacement. The SPCD card specifies only the magnitude of the enforced displacement. When an SPCD card is used, the component to be constrained must be specified on either an SPC or SPC1 card. The use of the SPCD card avoids

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the decomposition of the stiffness matrix when changes are only made in the magnitudes of the enforced displacements.

The equivalent loads resulting from enforced displacements of grid points are calculated by the program and added to the other applied loads. The magnitudes of the enforced displacements are specified on SPC cards (SPCAX in the case of conical shell problems) in the global coordinate system. The application of the load is automatic when the user selects the associated SPC set in the Case Control Deck.

The LØAD card in the Bulk Data Deck defines a static loading condition that is a linear combination of load sets consisting of loads applied directly to grid points, pressure loads, gravity loads and centrifugal forces. This card must be used if gravity loads are to be used in combination with loads applied directly to grid points, pressure loads or centrifugal forces. The application of the combined loading condition is requested in the Case Control Deck by selecting the set number of the LØAD combination.

It should be noted that the equivalent loads (thermal, enforced deformation and enforced displacement) must have unique set identification numbers and be separately selected in the Case Control Deck. For any particular solution, the total static load will be the sum of the applied loads (grid point loading, pressure loading, gravity loading and centrifugal forces) and the equivalent loads.

1.5.2 Frequency Dependent Loads

A discussion of frequency response calculations is given in Section 12.1 of the Theoretical Manual. The DLØAD card is used to define linear combinations of frequency dependent loads that are defined on RLØAD1 or RLØAD2 cards. The RLØAD1 card defines a frequency dependent load of the form

$$\{P(f)\} = \left\{ A[C(f) + iD(f)]e^{i(\theta - 2\pi f\tau)} \right\}, \quad (1)$$

where A is defined on a DAREA card, C(f) and D(f) are defined on TABLEDi cards, θ is defined on a DPHASE card and τ is defined on a DELAY card. The RLØAD2 card defines a frequency dependent load of the form

$$\{P(f)\} = \left\{ AB(f)e^{i\{\phi(f) + \theta - 2\pi f\tau\}} \right\}, \quad (2)$$

where A is defined on a DAREA card, B(f) and $\phi(f)$ are defined on TABLEDi cards, θ is defined on a

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DPHASE card, and τ is defined on a DELAY card. The coefficients on the DAREA, DELAY and DPHASE cards may be different for each loaded degree of freedom. The loads are applied to the specified components in the global coordinate system.

A discussion of random response calculations is given in Section 12.2 of the Theoretical Manual. The RANDPS card defines load set power spectral density factors for use in random analysis of the form

$$S_{jk}(f) = (X + iY)G(f) \quad , \quad (3)$$

where $G(f)$ is defined on a TABRNDi card. The subscripts j and k define the subcase numbers of the load definitions. If the applied loads are independent, only the diagonal terms ($j=k$) need be defined. The RANDT1 card is used to specify the time lag constants for use in the computation of the autocorrelation functions.

1.5.3 Time Dependent Loads

A discussion of transient response calculations is given in Section 11 of the Theoretical Manual. The DLØAD card is used to define linear combinations of time dependent loads that are defined on TLØAD1 and TLØAD2 cards. The TLØAD1 card defines a time dependent load of the form

$$\{P(t)\} = \{AF(t - \tau)\} \quad , \quad (4)$$

where A is defined on a DAREA card, τ is defined on a DELAY card, and $F(t-\tau)$ is defined on a TABLEDi card. The TLØAD2 card defines a time dependent load of the form

$$\{P(t)\} = \begin{cases} \{0\} \quad , \quad \tilde{t} < 0 \quad \text{or} \quad \tilde{t} > T_2 - T_1 \\ \{A\tilde{t}^B e^{C\tilde{t}} \cos(2\pi f\tilde{t} + P)\} \quad , \quad 0 < \tilde{t} < T_2 - T_1 \end{cases} \quad , \quad (5)$$

where $\tilde{t} = t - T_1 - \tau$ and A and τ are defined as above. The coefficients on the DAREA and DELAY cards may be different for each loaded degree of freedom. The loads are applied to the specified components in the global coordinate system.

Nonlinear effects are treated as an additional applied load vector, for which the components are functions of the degrees of freedom. This additional load vector is added to the right side of the equations of motion and treated along with the applied load vector during numerical inte-

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gration. It is required that the points to which the nonlinear loads are applied and the degrees of freedom on which they depend be members of the solution set, i.e., that they cannot be degrees of freedom eliminated by constraints. It is further required, that if a modal formulation is used, the points referenced by the nonlinear loads be members of the set of extra scalar points introduced for dynamic analysis.

At present, NASTRAN includes four different types of nonlinear elements. For a discussion of nonlinear elements see Section 11.2 of the Theoretical Manual. The NØLIN1 card defines a nonlinear load of the form

$$P_i(t) = S_i T(u_j) \quad (6)$$

where P_i is the load applied to u_i , S_i is a scale factor, $T(u_j)$ is a tabulated function defined with a TABLEDi card, and u_j is any permissible displacement component. The NØLIN2 card defines a nonlinear load of the form

$$P_i(t) = S_i u_j u_k \quad (7)$$

where u_j and u_k are any permissible pair of displacement components. They may be the same. The NØLIN3 card defines a nonlinear load of the form

$$P_i(t) = \begin{cases} S_i (u_j)^A & , \quad u_j > 0 \\ 0 & , \quad u_j \leq 0 \end{cases} \quad (8)$$

where A is an exponent. The NØLIN4 card defines a nonlinear load of the form

$$P_i(t) = \begin{cases} -S_i (-u_j)^A & , \quad u_j < 0 \\ 0 & , \quad u_j \geq 0 \end{cases} \quad (9)$$

Nonlinear loads applied to a massless system without damping will not converge to a steady state solution. Use of DIAG 10 (Section 2.2.1) will cause the nonlinear term $\{N_{n+1}\}$ to be replaced by $1/3 \{N_{n+1} + N_n + N_{n-1}\}$ where N_{n+1} , N_n and N_{n-1} are the values of the nonlinear loads at time steps preceding the solution time step. Section 11.3 of the Theoretical Manual discusses the integration equations.

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1.6 DYNAMIC MATRICES

The dynamic matrices are defined as the stiffness, mass and damping matrices used in either the direct or modal formulation of dynamics problems. The assembly of dynamics matrices is discussed in Section 9.3 of the Theoretical Manual. There are three general sources for the elements of the dynamic matrices.

1. Matrices generated by the Structural Matrix Assembler.
2. Direct input matrices.
3. Modal matrices obtained from real eigenvalue analysis.

The Structural Matrix Assembler generates stiffness terms from the following sources:

1. Structural elements defined on connection cards, e.g., CBAR and CRØD.
2. General elements defined on GENEL cards.
3. Scalar springs defined on CELASi cards.

The Structural Matrix Assembler generates mass terms from the following sources:

1. A 6x6 matrix of mass coefficients at a grid point defined on a CØNM1 card.
2. A concentrated mass element defined on a CØNM2 card in terms of its mass and moments of inertia about its center of gravity.
3. Structural mass for all elements, except plate elements without membrane stiffness, using the mass density on the material definition card.
4. Nonstructural mass for all elements specifying a value on the property card.
5. Scalar masses defined on CMASSi cards.

A discussion of inertia properties, including the Lumped Mass method and the Coupled Mass method are given in Section 5.5 of the Theoretical Manual. The Structural Matrix Assembler will use the Lumped Mass method for bars, rods and plates unless the PARAM card CØUPMASS (see PARAM bulk data card) used to request the Coupled Mass method.

The Structural Matrix Assembler generates damping terms from the following sources:

1. Viscous rod elements defined on CVISC cards.
2. Scalar viscous dampers defined on CDAMPi cards.
3. Element structural damping by multiplying the stiffness matrix of an individual structural element by a damping factor obtained from the material properties (MATi) card for the element.

In addition, uniform structural damping is provided by multiplying the stiffness matrix generated

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in Structural Matrix Assembler by a damping factor that is specified by the user on the PARAM card G (see PARAM bulk data card). This form of damping is not recommended for hydroelastic problems.

The direct input matrices are generated by transfer functions (TF cards) or they are supplied directly by the user (DMIG or DMIAX cards). The terms of the direct input matrices may be associated either with grid points or with extra points introduced for dynamic analysis.

The modal matrices are obtained from real eigenvalue analysis using the stiffness and mass matrices generated by the Structural Matrix Assembler.

1.6.1 Direct Formulation

In the direct method of dynamic problem formulation, the degrees of freedom are simply the displacements at grid points. The dynamic matrices are assembled from the direct input matrices and the stiffness, mass and damping matrices generated by the Structural Matrix Assembler. The direct input matrices are generated by transfer functions (TF cards) or they are supplied directly by the user (DMIG or DMIAX cards).

For frequency response analysis and complex eigenvalue analysis the complete dynamic matrices are:

$$[K_{dd}] = (1 + ig)[K_{dd}^1] + [K_{dd}^2] + i[K_{dd}^4], \quad (1)$$

$$[B_{dd}] = [B_{dd}^1] + [B_{dd}^2], \quad (2)$$

$$[M_{dd}] = [M_{dd}^1] + [M_{dd}^2], \quad (3)$$

where the subscripts dd indicate the solution set composed of the degrees of freedom remaining after all constraints have been applied and the extra scalar points introduced for dynamic analysis. The matrices K, B and M are the stiffness, damping and mass matrices respectively. The superscript 1 indicates the matrices generated by the Structural Matrix Assembler. The superscript 2 indicates the direct input matrices. The matrix $[K_{dd}^4]$ is a structural damping matrix obtained by multiplying the stiffness matrix of an individual structural element by a damping factor obtained from the material properties (MATi) card for the element. The matrix $[K_{dd}^1]$ is multiplied by the damping factor (g) to provide for uniform structural damping in cases where it is appropriate. The constant g is specified by the user on a PARAM card (see PARAM bulk data card).

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For transient response analysis the complete dynamic matrices are:

$$[K_{dd}] = [K_{dd}^1] + [K_{dd}^2] \quad , \quad (4)$$

$$[B_{dd}] = [B_{dd}^1] + [B_{dd}^2] + \frac{g}{\omega_3}[K_{dd}^1] + \frac{1}{\omega_4}[K_{dd}^4] \quad , \quad (5)$$

$$[M_{dd}] = [M_{dd}^1] + [M_{dd}^2] \quad , \quad (6)$$

where ω_3 is the radian frequency at which the term $\frac{g}{\omega_3}[K_{dd}^1]$ produces the same magnitude of damping as the term $ig[K_{dd}^1]$ in frequency response analysis, and ω_4 is the radian frequency at which the term $\frac{1}{\omega_4}[K_{dd}^4]$ produces the same magnitude of damping as the term $i[K_{dd}^4]$ in frequency response analysis. The equivalent viscous damping is only an approximation to the structural damping as the viscous damping forces are larger at higher frequencies and smaller at lower frequencies. Therefore, the quantities ω_3 and ω_4 are frequently selected by the user to be at the center of the frequency range of interest. A small value of g/ω_3 is frequently useful to insure stability of higher modes in nonlinear transient analysis. The user specifies the values of ω_3 and ω_4 on PARAM cards W3 and W4 (see PARAM bulk data card). If ω_3 and ω_4 are omitted, the corresponding terms are ignored.

1.6.2 Modal Formulation

In the modal method of dynamic problem formulation, the vibration modes of the structure in a selected frequency range are used as degrees of freedom, thereby reducing the number of degrees of freedom while maintaining accuracy in the selected frequency range. The frequency range is specified on PARAM cards by either selecting the number of lowest modes obtained from a real eigenvalue analysis or selecting all of the modes in a given frequency range (see PARAM bulk data card).

It is important to have both direct and modal methods of dynamic problem formulation, in order to maximize efficiency in different situations. The modal method will usually be more efficient in problems where a small fraction of all of the modes are sufficient to produce the desired accuracy, provided that the bandwidth of the direct stiffness matrix is large. The bandwidth may be large due either to a compact structural arrangement or to dynamic coupling effects. The direct method will usually be more efficient for problems in which the bandwidth of the direct stiffness matrix is small and for problems with dynamic coupling in which a large

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fraction of the vibration modes are required to produce the desired accuracy. For problems without dynamic coupling, i.e., for problems in which the matrices of the modal formulation are diagonal, the modal method will frequently be more efficient, even though a large fraction of the modes are needed.

The complete dynamic matrices used in dynamic analysis by the modal method include the direct input mass, damping and stiffness matrices $[M_{dd}^2]$, $[B_{dd}^2]$, $[K_{dd}^2]$, and the modal matrices $[m_i]$, $[b_i]$ and $[k_i]$, obtained from real eigenvalue analysis. The matrix $[m_i]$ is the modal mass matrix with off-diagonal terms (which should be zero) omitted. The modal damping matrix $[b_i]$ and stiffness matrix $[k_i]$ are obtained from $[m_i]$ by:

$$[b_i] = [2\pi f_i g(f_i) m_i] \quad , \quad (7)$$

$$[k_i] = [4\pi^2 f_i^2 m_i] \quad , \quad (8)$$

where f_i is the frequency of the i^{th} normal mode and $g(f_i)$ is obtained by interpolation of a table supplied by the user to represent the variation of structural damping with frequency. This table is defined with a TABDMP1 card. Structural damping will not be used in the modal formulation unless an SDAMPING card is used in the Case Control Deck to select a particular TABDMP1 card. The specification of damping properties for the modal method is somewhat less general than it is for the direct method, in that viscous dampers and nonuniform structural damping are not used.

The mode acceleration method of data recovery is optional when using the modal formulation for transient response and frequency response problems, see Section 9.4 of the Theoretical Manual for details. In this procedure, the inertia and damping forces are computed from the modal solution. These forces are then added to the applied forces and the combination is used to obtain a more accurate displacement vector for the structure by static analysis. This improved displacement vector is used in the stress recovery operation. The mode acceleration method is selected with the PARAM card M0DACC (see PARAM bulk data card).

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1.7 HYDROELASTIC MODELING

1.7.1 Solution of the NASTRAN Fluid Model

The NASTRAN hydroelastic option allows the user to solve a wide variety of fluid problems having structural interfaces, compressibility, and gravity effects. A complete derivation of the NASTRAN model and an explanation of the assumptions are given in the Theoretical Manual, Section 16.1. The input data and the solution logic have many similarities to a structural model. The standard normal modes analysis, transient analysis, complex eigenvalue analysis, and frequency response solutions are available with minor restrictions. The differences between a NASTRAN fluid model and an ordinary structural problem are due to the physical properties of a fluid, and are:

1. The independent degrees of freedom for a fluid are the Fourier coefficients of the pressure function (i.e. "harmonic pressures") in an axisymmetric coordinate system. The independent degrees of freedom for a structure are typically displacements and rotations at a physical point in space.
2. Much like the structural model, the fluid data will produce "stiffness" and "mass" matrices. Because they now relate pressures and flow instead of displacement and force, their physical meaning is quite different. The user may not apply loads, constraints, sequencing, or omitted coordinates "directly" on the fluid points involved. Instead, the user supplies information related to the boundaries and NASTRAN internally generates the correct constraints, sequencing, and matrix terms. Indirect methods, however, are available to the user for utilizing the internally generated points as normal grid or scalar points. See Section 1.7.4 for the identification code.
3. When a physical structure is to be connected to the fluid, the user supplies a list of fluid points and a related list of special structural grid points. NASTRAN will produce unsymmetric matrix terms which define the actual physical relations. A special provision is included in NASTRAN in the event that the structure has planes of symmetry. The user may, if he wishes, define only a section of the boundary and solve his problem with symmetric or antisymmetric constraints. The fluid-structure interface will take the missing sections of structural boundary into account.

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4. Because of the special nature of the fluid problems, various user convenience options are absent. The fluid elements and harmonic pressures may not be included in the structural plots at present. Plotting the harmonic pressures versus frequency or time may not be "directly" requested. Because mass matrix terms are automatically generated if compressibility or free surface effects are present, the weight and C.G. calculations with fluid elements present may not be correct and should be avoided. Also, the inertia relief rigid format uses the mass matrix to produce internal loads and if fluids are included, these special fluid terms in the mass matrix may produce erroneous results.

In spite of the numerous differences between a NASTRAN structural model and a NASTRAN fluid model, the similarities allow the user to formulate a model with a minimum of data preparation and obtain efficient solutions to large order problems. The similarities of the fluid model to the NASTRAN structural model are:

1. The fluid is described by points in space and finite element connections. The locations of the axisymmetric fluid points are described by rings (RINGFL) about a polar axis, much like the axisymmetric conical shell. The rings are connected by elements (CFLUIDi) which have the properties of density and bulk modulus of compressibility. Each fluid ring produces, internally, a series of NASTRAN scalar points, P^n and P^{n*} (i.e. "harmonic pressures"), describing the pressure function, $P(\phi)$, in the following equation:

$$P(\phi) = P^0 + \sum_{n=1}^N P^n \cos n\phi + \sum_{n=1}^N P^{n*} \sin n\phi \quad 0 < N < 100$$

where the set of harmonics 0, n and n* are selected by the user. If the user desires the output of pressure at specific points on the circular ring, he may specify them as "pressure points" (PRESPT) by giving a point number and an angle on a specified fluid ring. The output data will have the values of pressure at the angle, ϕ , given in the above equation. The output of free surface displacements normal to the surface (FREEPT) are also available at specified angles, ϕ . The case control card option "AXISYM=FLUID" is necessary when any harmonic fluid degrees of freedom are included.

2. The input data to NASTRAN may include all of the existing options except the axisymmetric structural element data. All of the existing case control options may be included with some additional fluid case control requests. All of the structural element and constraint

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data may be used (but not connected to RINGFL, PRESPT, or FREEPT fluid points). The structure-fluid boundary is defined with the aid of special grid points (GRIDB) which may be used for any purpose that a structural grid point is presently used.

3. The output data options for the structural part of a hydroelastic model are unchanged from the existing NASTRAN options. The output values for the fluid will be produced in the same form as the displacement vectors but with format modifications for the harmonic data. Printed values for the fluid may include both real and complex values. Pressures and free surface displacements, and their velocities and accelerations, may be printed with the same request (the case control request PRESSURE=SET is equivalent to DISP=SET) as structural displacements, velocities and accelerations. Structural plots are restricted to GRID and GRIDB points and any elements connected to them. X-Y plot and Random Analysis capability are available for FREEPT and PRESPT points if they are treated as scalar points. The RINGFL point identification numbers may not be used in any plot request, instead the special internally generated points used for harmonics may be requested in X-Y plots and Random Analysis. See Section 1.7.4 for the identification number code. No element stress or force data is produced for the fluid elements. As in the axisymmetric conical shell problem the case control request HARMONICS=N is used to select up to the Nth harmonic for output.

1.7.2 Hydroelastic Input Data

A number of special NASTRAN data cards are required for fluid analysis problems. These cards are compatible with structural NASTRAN data. The NASTRAN RESTART feature will be available in Rigid Format Series M for changes in these data cards. A brief description of the uses for each bulk data card follows.

AXIF

This card controls the formulation of the axisymmetric fluid problem. It is a required card if any of the subsequent fluid related cards are present. The data references a fluid related coordinate system to define the axis of symmetry. The gravity parameter is included on the card rather than on the GRAV card because the direction of gravity must be parallel to the axis of symmetry. The values of density and bulk elastic modulus are conveniences in the event that these properties are constant throughout the fluid. A list of harmonics and the request for the nonsym-

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metric (sine) coefficients are included on this card to allow the user to select any of the harmonics without producing extra matrix terms for the missing harmonics. A change in this list, however, will require a RESTART at the beginning of the problem.

RINGFL

The geometry of the fluid model about the axis of symmetry is defined with the aid of these data cards. The RINGFL data cards serve somewhat the same function for the fluid as the GRID cards serve in the structural model. In fact, each RINGFL card will produce, internally, a special grid point for each of the various harmonics selected on the AXIF data card. They may not, however, be connected directly to normal NASTRAN structural elements (see GRIDB and BDYLIST data cards). No constraints may be applied directly to RINGFL fluid points.

CFLUIDi

The data on these cards are used to define a volume of fluid bounded by the referenced RINGFL points. The volume is called an element and logically serves the same purpose as a structural finite element. The physical properties (density and bulk modulus) of the fluid element may be defined on this card if they are variables with respect to the geometry. If a property is not defined, the default value on the AXIF card is assumed. Two connected circles (RINGFL) must be used to define fluid elements adjacent to the axis of symmetry. A choice of three or four points is available in the remainder of the fluid.

GRIDB

This card provides an alternate to the GRID card for the definition of structural grid points. It also identifies the structural grid point with a particular RINGFL fluid point for hydroelastic problems. The particular purpose for this card is to force the user to place structural boundary points in exactly the same locations as the fluid points on the boundary. The format of the GRIDB card is identical to the format of the GRID card except that one additional field is used to identify the RINGFL point. The GRDSET card, however, is not used for GRIDB data.

If the user desires, he may use GRIDB cards without a fluid model. This is convenient in case the user wished to solve his structural problem first and to add the fluid effects later without converting GRID cards to GRIDB cards. The referenced RINGFL point must still be included in a boundary list (BDYLIST), see below, and the AXIF card must always be present when GRIDB cards are used. (The fluid effects are eliminated by specifying no harmonics.)

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FREEPT, PRESPT

These cards are used to define points on a free surface for surface displacement output and points in the fluid for pressure output. No constraints may be applied to these points. Scalar elements and direct matrix data may be connected to these points, but the physical meaning of the elements will be different than in the structural sense.

FSLIST, BDYLIST

The purpose for these cards is to allow the user to define the boundaries of the fluid with a complete freedom of choice. The FSLIST card defines a list of fluid points which lie on a free surface. The BDYLIST data is a list of fluid points to which structural GRIDB points are connected. Points on the boundary of the fluid for which BDYLIST or FSLIST data are not defined are assumed to be rigidly restrained from motion in a direction normal to the surface.

With both of these lists the sequence of the listed points determines the nature of the boundary. The following directions will aid the user in producing a list.

1. Draw the z axis upward and the r axis to the right. Plot the locations of the fluid points on the right hand side of z.
2. If one imagines himself traveling along the free surface or boundary with the fluid on his right side the sequence of points encountered is used for the list. If the surface or boundary touches the axis, the word "AXIS" is placed in the list. "AXIS" may be used only for the first and/or last point in the list.
3. The free surface must be consistent with static equilibrium. With no gravity field, any free surface consistent with axial symmetry is allowed. With gravity, the free surface must be a plane perpendicular to the z axis of the fluid coordinate system.
4. Multiple free surface lists and boundary lists are allowed. A fluid point may be included in any number of lists.

Figure 1.7-1 illustrates a typical application of the free surface and structural boundary lists.

FLSYM

This card allows the user to optionally model a portion of the structure with planes of symmetry containing the polar axis of the fluid. The first plane of symmetry is assumed at

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$\phi = 0.0$ and the second plane of symmetry is assumed at $\phi = 360^\circ/M$ where M is an integer specified on the card. Also specified are the types of symmetry for each plane, symmetric (S) or antisymmetric (A). The user must also supply the relevant constraint data for the structure. The solution is performed correctly only for those harmonic coefficients that are compatible with the symmetry conditions as illustrated in the following example for quarter symmetry, $M = 4$.

Series	Plane 1	Plane 2	
		S	A
Cosine	S	0,2,4,...	1,3,5,...
	A	none	none
Sine (*)	S	none	none
	A	1,3,5,...	2,4,6,...

DMIAX

These cards are used for Direct Matrix Input for special purposes such as surface friction effects. They are equivalent to the DMIG cards, the only difference being the capability to specify the harmonic numbers for the degrees of freedom. A matrix may be defined with either DMIG or DMIAX cards, but not with both.

1.7.3 Rigid Formats

The characteristics of the fluid analysis problems which cause restrictions on the type of solution are:

1. The fluid-structure interface is mathematically described by a set of unsymmetric matrices. Since the first six Rigid Formats are restricted to the use of symmetric matrices, the fluid-structure boundary is ignored. Thus, for any of these Rigid Formats the program solves the problem for a fluid in a rigid container with an optional free surface and an uncoupled elastic structure with no fluid present.
2. No means are provided for the direct input of applied loads on the fluid. The only direct means of exciting the fluid is through the structure-fluid boundary. The fluid problem may be formulated in any rigid format. However, only some will provide nontrivial solutions.

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The suggested Rigid Formats for the axisymmetric fluid and the restrictions on each are described below:

Rigid Format No. 3 - Normal Modes Analysis

The modes of a fluid in a rigid container may be extracted with a conventional solution request. Free surface effects with or without gravity may be accounted for. Any structure data in the deck will be treated as a disjoint problem. (The structure may also produce normal modes.) Normalization of the eigenvectors using the PØINT option will cause a fatal error.

Rigid Format No. 7 - Direct Complex Eigenvalue Analysis

The coupled modes of the fluid and structure must be solved with this rigid format. If no damping or direct input matrices are added, the resulting complex roots will be purely imaginary numbers, whose values are the natural frequencies of the system. The mode shape of the combination may be normalized to the maximum quantity (harmonic pressure or structural displacement) or to a specified structural point displacement.

Rigid Format No. 8 - Direct Frequency and Random Response

This solution may be used directly if the loads are applied only to the structural points. The use of overall structural damping (parameter g) is not recommended since the fluid matrices will be affected incorrectly. Output restrictions are listed on page 1.7-3.

Rigid Format No. 9 - Direct Transient Response

Transient analysis may be performed directly on the fluid-structure system if the following rules apply.

1. Applied loads and initial conditions are only given to the structural points.
2. All quantities are measured relative to static equilibrium. The initial values of the pressures are assumed to be at equilibrium.
3. Overall structural damping (parameters ω_3 and g) must not be used.
4. Output restrictions are listed on page 1.7-3.

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Rigid Formats 10, 11, and 12 - Modal Formulations

Although these rigid formats may be used in a fluid dynamics problem, their practicality is limited. The modal coordinates used to formulate the dynamic matrices will be the normal modes of both the fluid and the structure solved as uncoupled systems. Even though the range of natural frequencies would be typically very different for the fluid than for the structure, NASTRAN will select both sets of modes from a given fixed frequency range. The safest method with the present system is the extraction of all modes for both systems with the Tridiagonalization Method. This procedure, however, results in a dynamic system with large full matrices. The Direct Formulation would be more efficient in that case. At present, the capability for fluid-structure boundary coupling is not provided with Rigid Formats 10, 11 and 12. However the capability may be provided by means of an ALTER using the same logic as in the direct formulations.

1.7.4 Hydroelastic Data Processing

The fluid related data cards submitted by the user are processed by the NASTRAN preface module to produce equivalent grid point, scalar point, element connection, and constraint data card images. Each specified harmonic, N, of the Fourier series solution produces a complete set of special grid and connection card images. In order to retain unique identification numbers the user identification numbers are encoded by the algorithm below:

RINGFL points:

$$\text{NASTRAN grid Id.} = \text{User ring Id.} + 1,000,000 \times I_N$$

where

$$I_N = N + 1 \quad \text{cosine series}$$

$$I_N = N + 1/2 \quad \text{sine series}$$

CFLUIDi connection cards:

$$\text{NASTRAN element Id.} = \text{User element Id.} \times 1000 + I_N$$

where I_N is defined above for each harmonic N.

For example, if the user requested all harmonics from zero to two, including the sine(*) series, each RINGFL card will produce five special grid cards internally. If the user's Identifi-

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cation number (in field 2 of the RINGFL data card) were 37, the internally generated grid points would have the following identification numbers:

<u>Harmonic</u>	<u>Id.</u>
0	1,000,037
1*	1,500,037
1	2,000,037
2*	2,500,037
2	3,000,037

These equivalent grid points are resequenced automatically by NASTRAN to be adjacent to the original RINGFL identification number. A RINGFL point may not be resequenced by the user.

The output from matrix printout, table printout, and error messages will have the fluid points labeled in this form. If the user wishes, he may use these numbers as scalar points for Random Analysis, X-Y plotting, or for any other purpose.

In addition to the multiple sets of points and connection cards, the NASTRAN preface also may generate constraint sets. For example if a free surface (FSLIST) is specified in a zero-gravity field, the pressures are constrained by NASTRAN to zero. For this case the internally generated set of single point constraints are internally combined with any user defined structural constraints and will always be automatically selected.

If pressures at points in the fluid (PRESPT) or gravity dependent normal displacements on the free surface (FREEPT) are requested, the program will convert them to scalar points and create a set of multipoint constraints with the scalar points as dependent variables. The constraint set will be internally combined with any user defined sets and will be selected automatically.

The PRESPT and FREEPT scalar points may be used as normal scalar points for purposes such as plotting versus frequency or time. Although the FREEPT values are displacements, scalar elements connected to them will have a different meaning than in the structural sense.

1.7.5 Sample Hydroelastic Model

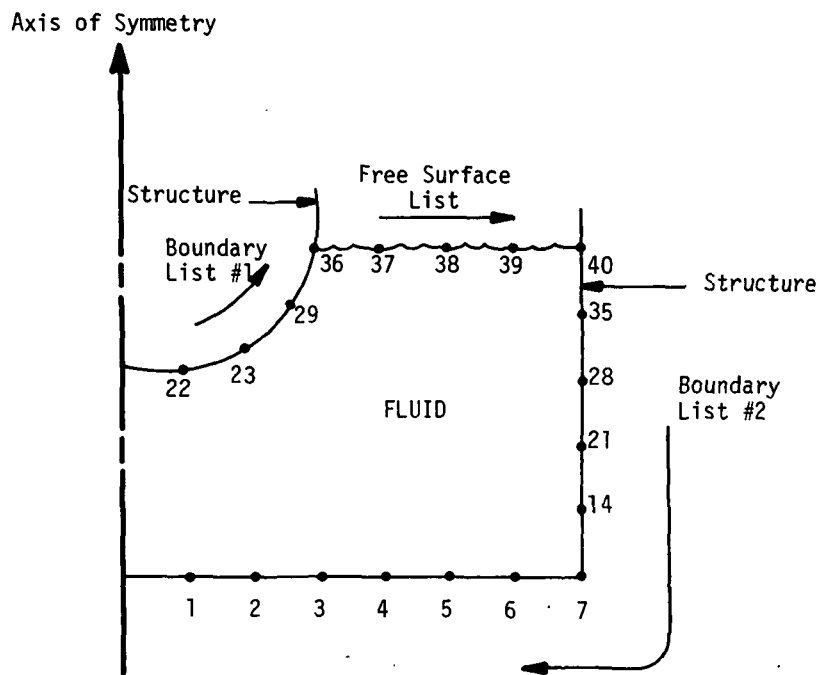
Table 1.7-1 contains a list of the data deck for a sample hydroelastic problem. Figure 1.7-2 describes the problem and lists the parameters. The relatively small number of grid points were chosen for purposes of simplicity, and not accuracy. The special cards for hydroelastic analysis are flagged with the symbol (+). The symbols for the fields in the hydroelastic data cards are

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placed above each group. Structural data cards are included in their standard formats. The explanations for the data are given in the following notes:

1. The "AXISYM=FLUID" card is necessary to control the constraint set selections and the output formats for a fluid problem. It must appear above the subcase level.
2. "DISPLACEMENT=" and "PRESSURE=" case control cards are pseudonyms. "DISP=ALL" will produce all structure displacements, free surface displacements, and all fluid pressure values in the output. The "HARMONICS=" control is a limit on the harmonic data and has the same function as in an axisymmetrical conical shell problem.
3. The AXIF card defines the existence of a hydroelastic problem. It is used to define overall parameters and control the harmonic degrees of freedom.
4. The RINGFL cards included will define the five points on the fluid cross section.
5. The CFLUIDi cards are used to define the volume of the fluid as finite elements connected by the RINGFL points. Since parameters ρ and B are missing, the default values on the AXIF card will be used.
6. The FSLIST card is used to define the free surface at $z = 10.0$. The density factor, ρ , is placed on the card in this case. If blank, the default value on the AXIF card is used.
7. The fluid-structure boundary is defined on the BDYLIST card. The AXIF default density is used.
8. The GRIDB cards define the structure points on the fluid boundary. Points #3 through #6 are connected to the #2 fluid ring. The rotation in the r direction ("4" in field 8) is constrained.
9. The fact that one-quarter symmetry was used for the structure requires the use of the FLSYM card. Symmetric-Antisymmetric boundaries indicate that only the cosine terms for the odd harmonics will interact with the structure. If Symmetric-Symmetric boundary conditions were chosen on the FLSYM data card, only the even harmonics of the cosine series would interact with the structure.

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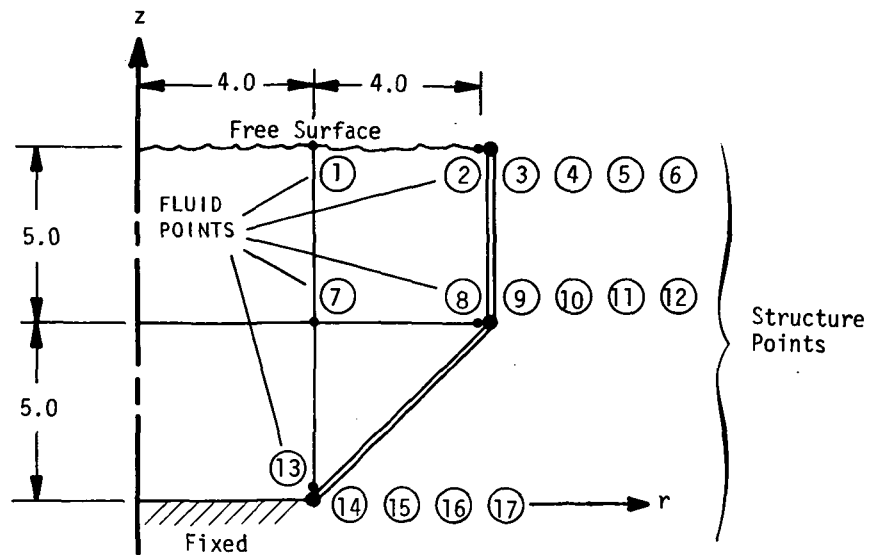
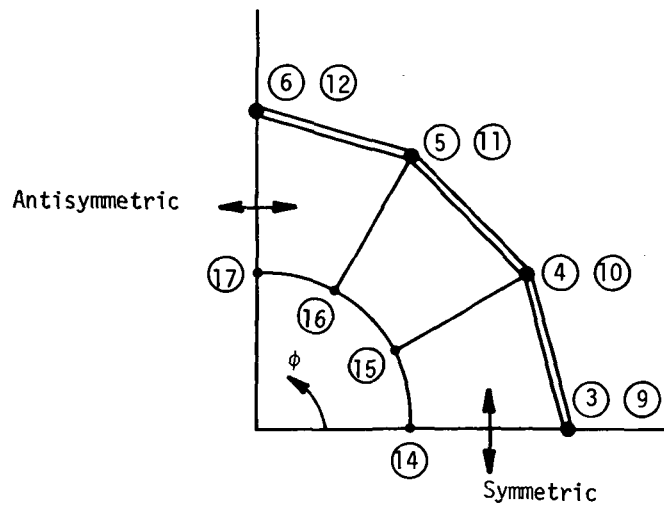


FSLIST: 36, 37, 38, 39, 40

BDYLIST #1: AXIS, 22, 23, 29, 36

BDYLIST #2: 40, 35, 28, 21, 14, 7, 6, 5, 4, 3, 2, 1, AXIS

Figure 1.7-1 Examples of boundary lists.



Fluid: Density, $\rho = 0.03$
Bulk Modulus, $B = \infty$
Gravity, $g = 32.2$

Structure: Thickness, $t = 0.5$
Density, $\rho = 0.05$

Figure 1.7-2 Sample hydroelastic problem.

1

•

(2)

(3)

i

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	1	2	3	4	5	6	7	8	9	10
		(Id)			(ϕ)		(CID)	(P-SPC)	(IDF)	
(+)	GRIDB	3			0.0		2	4	2	
	GRIDB	4			30.0		2	4	2	
	GRIDB	5			60.0		2	4	2	
	GRIDB	6			90.0		2	4	2	
	GRIDB	9			0.		2		8	
	GRIDB	10			30.		2		8	
	GRIDB	11			60.		2		8	
	GRIDB	12			90.		2		8	
	GRIDB	14			0.		2		13	
	GRIDB	15			30.		2		13	
	GRIDB	16			60.		2		13	
	GRIDB	17			90.		2		13	
	CQUAD2	10	11	3	9	10	4			
	CQUAD2	11	11	4	10	11	5			
	CQUAD2	12	11	5	11	12	6			
	CQUAD2	13	11	9	14	15	10			
	CQUAD2	14	11	10	15	16	11			
	CQUAD2	15	11	11	16	17	12			
	PQUAD2	11	12	0.5						
	MAT1	12	10.6+6		0.3	0.05				
	SPC1	3	246	3	9	14				
	SPC1	3	135	6	12	17				
	SPC1	3	135	14	15	16				
		(M)	(S1)	(S2)						
(+)	FLSYM	4	S	A						
	EIGC	1	INV	MAX						+EI
	+EI	0.	0.	0.	5.	3.	2	2		
	ENDDATA									

(+) Hydroelastic cards

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1.8 HEAT TRANSFER PROBLEMS

1.8.1 Introduction to NASTRAN Heat Transfer

NASTRAN heat flow capability may be used either as a separate analysis to determine temperatures and fluxes, or to determine temperature inputs for structural problems. Steady and transient problems can be solved, including heat conduction (with variable conductivity for static analysis), film heat transfer, and nonlinear (fourth power law) radiation.

The heat flow problem is similar, in many ways, to structural analysis. The same grid points, coordinate systems, elements, constraints, and sequencing can be used for both problems. There are several differences, such as the number of degrees of freedom per grid point, the methods of specifying loads, boundary film heat conduction, and the nonlinear elements. For heat flow problems, the only unknown at a grid point is the temperature (cf. structural analysis with three translations and three rotations), and hence, there is one degree of freedom per grid point. Additional grid or scalar points are introduced for ambient temperatures in film heat transfer. If the conductivity of an element is temperature dependent, the problem becomes nonlinear (cf. structural analysis with temperature dependent materials which only requires looking up material properties and computing thermal loads).

The heat conduction analysis of NASTRAN is compatible with structural analysis. If the same finite elements are appropriate, then the same grid and connection cards can be used for both problems. As in structural analysis, the choice of a finite element model is left to the analyst. Temperature distributions can be output in a format which can be input into structural problems. Heat flow analysis uses many structural NASTRAN bulk data cards. These include (where i means there is more than one type): CBAR, CDAMPi, CELASi, CHEXAi, CØNRØD, CØRDii, CQDMEM, CQDPLT, CQUADi, CRØD, CTETRA, CTRAPRG, CTRIAi, CTRIARG, CTRMEM, CTUBE, CVISC, CWEDGE, DAREA, DELAY, DLØAD, DMI, DMIG, EPØINT, GRDSET, GRID, LØAD, MPC, MPCADD, NØLINi, ØMITi, PARAM, Piii (for elements requiring properties), PLØTEL, SEQiP, SLØAD, SPCi, SPCADD, SPØINT, TABLEDi, TABLEMi, TEMPii, TF, TLØADi, and TSTEP.

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1.8.2 Heat Transfer Elements

The basic heat conduction elements are the same as NASTRAN structural elements. These elements are shown in the following table:

Heat Conduction Elements	
Type	Elements
Linear	BAR, RØD, CØNRØD, TUBE
Membrane	TRMEM, TRIA1, TRIA2, QDMEM, QUAD1, QUAD2
Solid of Revolution	TRIARG, TRAPRG
Solid	TETRA, WEDGE, HEXA1, HEXA2

A connection card (Cxxx) and, if applicable, a property card (Pxxx) is defined for each of these elements. Linear elements have a constant cross-sectional area. The offset on the BAR is treated as a perfect conductor (no temperature drop). For the membrane elements, the heat conduction thickness is the membrane thickness. The bending characteristics of the elements do not enter into heat conduction problems. The solid of revolution element, TRAPRG, has been generalized to accept general quadrilateral rings (i.e., the top and bottom need not be perpendicular to the z-axis for heat conduction). These heat conduction elements are composed of constant gradient lines, triangles, and tetrahedra. The quadrilaterals are composed of overlapping triangles, and the wedges and hexahedra from subtetrahedra. Gradients and fluxes may be output by requesting ELFØRCE.

Thermal material conductivities and heat capacities are given on MAT4 (isotropic) and MAT5 (anisotropic) bulk data cards. Temperature dependent conductivities are given on MATT4 and MATT5 bulk data cards, which can only be used for nonlinear static analysis. The heat capacity per unit volume is specified, which is the product of density and heat capacity per unit mass (ρC_p).

A special element (HBDY) defines an area for boundary conditions. There are five basic types, called PØINT, LINE, REV, AREA3, and AREA4 (the sixth type, ELCYL, is for use only with QVECT radiation). The HBDY is considered an element, since it can add terms to the conduction and heat capacity matrices. There is a CHBDY connection and PHBDY property card. When a film heat transfer condition is desired, film conductivity and heat capacity per unit area are specified on MAT4

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data cards. The ambient temperature is specified with additional points (GRID or SPØINT) listed on the CHBDY connection card. See Figure 1 for geometry.

Radiation heat exchange may be included between HBDY elements. A list of HBDY elements must be specified on a RADLST bulk data card. The emissivities are specified on the PHBDY cards. The Stefan-Boltzmann constant (SIGMA) and absolute reference temperature (TABS) are specified on PARAM bulk data cards. Radiation exchange coefficients (default is zero) are specified on RADMTX bulk data cards.

The several types of power input to the HBDY elements can be output by requesting "ELFØRCE".

1.8.3 Constraints and Partitioning

Constraints are applied to provide boundary conditions, represent "perfect" conductors, and provide other desired characteristics for the heat transfer model.

Single point constraints are used to specify the temperature at a point. The grid or scalar points are listed on SPC or SPC1 bulk data cards. The component on the data card can be "0" or "1". This declares the degree of freedom to be in the u_s set. The method of specifying temperature is dependent upon the problem type.

Algorithm	Value of u_s Used
Linear statics	Values defined on selected SPC cards.
Nonlinear statics	Values of the selected TEMP (MATERIAL) set.
Transient	$u_s = 0.0$ (special modeling techniques, such as a good conductor with a large power specified, can be used to enforce $u(t)$).

Multipoint constraints are linear relationships between temperatures at several grid points, and are specified on MPC cards. The first entry on an MPC card will be in the u_m set. The type of constraint is limited if nonlinear elements are present. If a member of set u_m touches a nonlinear (conduction or radiation) element, the constraint relationship is restricted to be an "equivalence". The term "equivalence" means that the value of the member of the u_m set will be

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equal to one of the members of the u_n set (a point not multipoint constrained). Those points not touching nonlinear elements are not so limited. The user will be responsible to satisfy the equivalence requirement, by having only two entries on the MPC data card, with equal (but opposite in sign) coefficients.

1.8.4 Thermal Loads

Thermal "loads" may be boundary heat fluxes or volume heat addition. As in the case of structural analysis, the method of specifying loads is different for static and transient analysis. The HBDY element is used for boundaries of conducting regions. Surface heat flux input can be specified for HBDY elements with QBDY1 and QBDY2 data cards. These two cards are for constant and (spatially) variable flux, respectively. Flux can be specified without reference to an HBDY element with the QHBDY data card. Vector flux, such as solar radiation, depends upon the angle between the flux and the element normal, and is specified for HBDY elements with the QVECT data card. This requires that the orientation of the HBDY element be defined. Volume heat addition into a conduction element is specified on a QVØL data card.

Static thermal loads are requested in case control with "LØAD" card. All of the above load types plus SLØAD's can be requested. Transient loads are requested in case control with a "DLØAD" card, which selects TLØAD time functions. Transient thermal loads may use DAREA (as in structural transient), and the QBDY1, QBDY2, QHBDY, QVECT, QVØL, and SLØAD cards.

1.8.5 Linear Static Analysis

Linear static analysis uses APPRoach HEAT, SØLution 1. The rigid format is the same as that used for static structural analysis. This implies that several loading conditions and constraint sets can be solved in one job, by using subcases in the Case Control Deck.

1.8.6 Nonlinear Static Analysis

Nonlinear static analysis uses APPRoach HEAT, SØLution 3. This rigid format will allow temperature dependent conductivities of the elements, nonlinear radiation exchange, and a limited use of multipoint constraints. There is no looping for load and constraints. The solution is iterative. The user can supply values on PARAM bulk data cards for:

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MAXIT (integer)	Maximum number of iterations (default 4).
EPSHT (real)	ϵ convergence parameter (default .001).
TABS (real)	Absolute reference temperature (default 0.0).
SIGMA (real)	Stefan-Boltzmann radiation constant (default 0.0).
IRES (integer)	Request residual vector output if positive (default -1).

The user must supply an estimate of the temperature distribution vector $\{u^1\}$. This estimate is used to calculate the reference conductivity plus radiation matrix needed for the iteration. $\{u^1\}$ is also used at all points in the u_s set to specify a boundary temperature. The values of $\{u^1\}$ are given on TEMP bulk data cards, and they are selected by TEMP(MATERIAL) in case control.

Iteration may stop for the following reasons:

1. Normal convergency: $\epsilon_T < \text{EPSHT}$, where ϵ_T is the per unit error estimate of the temperatures calculated.
2. Number of iterations $> \text{MAXIT}$.
3. Unstable: $|\lambda_1| < 1$ and the number of iterations > 3 , where λ_1 is a stability estimator.
4. Insufficient time to perform another iteration and output data.

The precise definitions are given in the NASTRAN Theoretical Manual, Section 8.4. Error estimates ϵ_p , λ_1 , and ϵ_T for all iterations may be output with the Executive Control Card DIAG 18, where ϵ_p is the ratio of the Euclidian norms of the residual (error) loads to the applied loads on the unconstrained degrees of freedom.

1.8.7 Transient Analysis

Transient analysis uses APPROACH HEAT, SOLUTION 9. This rigid format may include conduction, film heat transfer, nonlinear radiation, and NASTRAN nonlinear elements. Extra points are used as in structural transient analysis. All points associated with nonlinear loads must be in the solution set. Loads may be applied with TLØAD and DAREA cards as in structural analysis. Also, the thermal static load cards can be modified by a function of time for use in transient analysis. Loads are requested in case control with DLØAD. Initial temperatures are specified on TEMP bulk data cards and are requested by IC. Previous static or transient solutions can be easily used as initial conditions, since they can be punched in the correct format. An estimate of the temperature $\{u^1\}$ is specified on TEMP bulk data cards for transient with radiation, and is requested by TEMP(MATERIAL). The parameters available are:

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TABS (real) Absolute reference temperature (default 0.0).
SIGMA (real) Stefan-Boltzmann radiation constant (default 0.0).
BETA (real) Foreward difference integration factor (default .55).
RADLIN (integer) Radiation is linearized if positive (default -1).

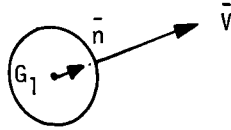
Time steps are specified on TSTEP data cards.

1.8.8 Compatibility with Structural Analysis

Grid point temperatures for thermal stress analysis (static structural analysis) are specified on TEMP bulk data cards. If punched output is requested in a heat conduction analysis, the format of the punched card is exactly that of a double field TEMP* data card. Thus, if the heat conduction model is the same as the structural model, the same grid, connection, and property cards can be used for both, and the temperature cards for the structural analysis are produced by the heat conduction analysis. The output request in case control is THERMAL(PUNCH).

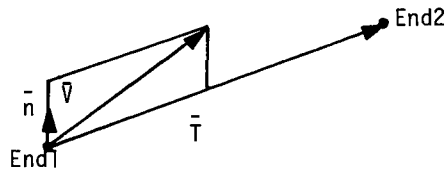
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Type = POINT



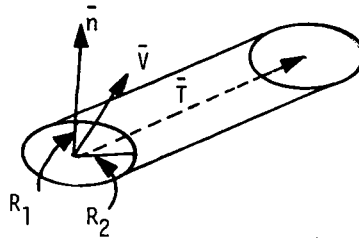
The unit normal vector is given by $\bar{n} = \bar{V}/|\bar{V}|$, where \bar{V} is given in the basic system at the referenced grid point (see CHBDY data card, fields 16-18).

Type = LINE



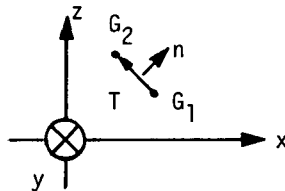
The unit normal lies in the plane of \bar{V} and \bar{T} , is perpendicular to \bar{T} , and is given by $\bar{n} = (\bar{T} \times (\bar{V} \times \bar{T})) / |\bar{T} \times (\bar{V} \times \bar{T})|$.

Type = ELCYL



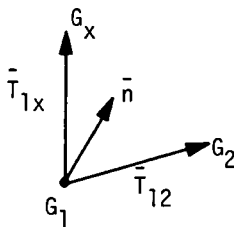
The same logic is used to determine \bar{n} as for type = LINE. The "radius" R_1 is in the \bar{n} direction, and R_2 is perpendicular to \bar{n} and \bar{T} (see fields 7 and 8 of PHBDY card).

Type = REV



The unit normal lies in the x-z plane, and is given by $\bar{n} = (\bar{e}_y \times \bar{T}) / |\bar{e}_y \times \bar{T}|$. \bar{e}_y is the unit vector in the y direction.

Type = AREA3 or AREA4



The unit normal vector is given by $\bar{n} = (\bar{T}_{12} \times \bar{T}_{1x}) / |\bar{T}_{12} \times \bar{T}_{1x}|$, where $x = 3$ for triangles and $x = 4$ for quadrilaterals.

Figure 1. HBDY Element Orientation (for QVECT flux).

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1.9 ACOUSTIC CAVITY MODELING

1.9.1 Data Card Functions

The NASTRAN structural analysis system is used as the basis for acoustic cavity analysis. Many of the structural analysis options such as selecting boundary conditions, applying loading conditions, and selecting output data are also available for acoustics.

The data cards specifically used for acoustic cavity analysis are described below. The card formats are exhibited in Section 2.4. Their purposes are analogous to the use of structural data cards. A gridwork of points is distributed over the longitudinal cross section of an acoustic cavity and finite elements are connected between these points to define the enclosed volume.

The points are defined by GRIDF data cards for the axisymmetric central fluid cavity and by GRIDS data cards for the radial slots. The GRIDF points are interconnected by finite elements via the CAXIF2, CAXIF3, and CAXIF4 data cards to define a cross sectional area of the body of rotation. The CAXIF2 element data card defines the area of the cross section between the axis and two points off the axis (the GRIDF points may not have a zero radius). The CAXIF3 and CAXIF4 data cards define triangular or quadrilateral cross sections and connect three or four GRIDF points respectively. The density and/or bulk modulus at each location of the enclosed fluid may also be defined on these cards.

The GRIDS points in the slot region are interconnected by finite elements via the CSLØT3 and CSLØT4 data cards. These define finite elements with triangular and quadrilateral cross-sectional shapes respectively. The width of the slot and the number of slots may be defined by default values on the AXSLØT data card. If the width of the slots is a variable, the value is specified on the GRIDS cards at each point. The number of slots, the density, and/or the bulk modulus of the fluid may also be defined individually, for each element on the CSLØT3 and CSLØT4 cards.

The AXSLØT data card is used to define the overall parameters for the system. Some of these parameters are called the "default" values and may be selectively changed at particular cross sections of the structure. The values given on the AXSLØT card will be used if a corresponding value on the GRIDS, CAXIFi, or CSLØTi is left blank. The parameters ρ (density) and B (bulk modulus) are properties of the fluid. If the value given for Bulk Modulus is zero the fluid is considered incompressible to the program. The parameters M (Number of slots) and W (slot width) are properties of the geometry. The parameter M defines the number of equally spaced slots

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around the circumference with the first slot located at $\phi = 0^\circ$. The parameter N (harmonic number) is selected by the user to analyze a particular set of acoustic modes. The pressure is assumed to have the following distribution

$$p(r,z,\phi) = p(r,z) \cos N\phi$$

If $N = 0$ the breathing and longitudinal modes will result. If $N = 1$ the pressure at $\phi = 180^\circ$ will be the negative of the pressure at $\phi = 0^\circ$. If $N = 2$, the pressures at $\phi = 90^\circ$ and $\phi = 270^\circ$ will be the negative of that at $\phi = 0^\circ$. Values of N larger than $M/2$ have no significance.

The interface between the central cavity and the slots is defined with the SLBDY data cards. The data for each card consists of the density of the fluid at the interface, the number of radial slots around the circumference, and a list of GRIDS points that are listed in the sequence in which they occur as the boundary is traversed. In order to ensure continuity between GRIDF and GRIDS points at the interface, the GRIDF points on the boundary between the cylindrical cavity and the slots are identified on the corresponding GRIDS data cards rather than on GRIDF cards. Thus, the locations of the GRIDF points will be exactly the same as the locations of the corresponding GRIDS points.

Various standard NASTRAN data cards may be used for special purposes in acoustic analysis. The SPC1 data card may be used to constrain the pressures to zero at specified points such as at a free boundary. The formats for these cards are included in Section 2.4. Dynamic load cards, direct input matrices, and scalar elements may be introduced to account for special effects. The reader is referred to Sections 1.4 and 1.5 for instruction in the use of these cards.

1.9.2 Assumptions and Limitations

The accuracy of the acoustic model will be dependent on the selection of the mesh of finite elements. The assumption for each element is that the pressure field has a linear variation over the cross section and a sinusoidal variation around the axis in the circumferential direction. In areas where the pressure gradient changes are large, such as near a sharp corner, the points in the mesh should be placed closer together so that large changes in flow may be defined accurately by the finite elements.

The shape of the finite elements play an important part in the accuracy of the results. It has been observed that long narrow elements produce disproportionate errors. Cutting a large

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square into two rectangles will not improve the results whereas dividing the square into four smaller squares may decrease the local error by as much as a factor of ten.

The slot portion of the cavity is limited to certain shapes because of basic assumptions in the algorithms. The cross section of the cavity normal to the axis must have a shape that is reasonably well defined by a central circular cavity having equally spaced, narrow slots. Various shapes are shown in Figure 1 in the order of increasing expected error.

It is recommended that shapes such as the cloverleaf and square cross section be analyzed with a full three dimensional technique. The assumption of negligible pressure gradient in the circumferential direction within a slot is not valid in these cases.

The harmonic orders of the solutions are also limited by the width of the slots. The harmonic number, N , should be no greater than the number of slots divided by two. The response of the higher harmonics is approximated by the slot width correction terms discussed in the NASTRAN Theoretical Manual, Section 17.1.

The output data for the acoustic analysis consists of the values of pressure in the displacement vector selected via the case control card "PRESSURE = i". The velocity vector components corresponding to each mode may be optionally requested by the case control card "STRESS = i", where i is the set number indicating the element numbers to be used for output, or by the words "STRESS = ALL". The "SET =" card lists the element or point numbers to be output.

Plots of the finite element model and/or of the pressure field may be requested with the NASTRAN plot request data cards. The central cavity cross section will be positioned in the XY plane of the Basic Coordinate System of NASTRAN. The slot elements are offset from the XY plane by the width of the slot in the +Z direction. The radial direction corresponds to X and the axial direction corresponds to the Y direction. Pressures will be plotted in the Z direction for both the slot points and the central cavity points. The case control data cards for plotting are documented in the User's Manual. The PLØTEL elements are used for plotting the acoustic cavity shape. The plot request card "SET n INCLUDE PLØTEL" must be used where n is a set number.

1.9.3 Acoustic Cavity Example Problem

Table 1 contains a listing of the data cards used as a simple example of acoustic cavity analysis. The problem to be solved is illustrated in Figure 2. The model was subdivided into

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only ten finite elements in order to limit the number of data cards. For reasonable engineering accuracy, this model should be subdivided into at least four times that number of elements.

Each data card in Table 1 is given a number on the left side. The format for each type of bulk data card is given in parentheses above the group of that type. The following is a brief description of each card:

Card(s)

- 1-5 Each data card in the Executive Control deck has the format of a request word and a selection separated by blanks or a comma. The ID card is first, the CEND card is last, but the intermediate cards may appear in any order. The user may put any pair of words on the ID card for identification purposes. In this particular case Rigid Format number 3 (SØL 3,0) was chosen which is Normal Modes analysis. A limit of 2 minutes CPU time was set (TIME 2).
- 6-7 The TITLE= and SUBTITLE= cards may contain any list of letters and numbers following the (=) sign. This list will appear on the first two lines of each output page.
- 8 The method of eigenvalue extraction is selected with the METHØD= data card. The number 11 refers to the identification number of an EIGR bulk data card which appears below as card 32 and 33.
- 9-11 A simple output request is illustrated with these cards. PRES=ALL will result in print-out of all pressures at the GRIDF and GRIDS points. STRESS=ALL will result in the print-out of all velocities in the elements. This printout will occur for all extracted eigenvectors. Selected points or elements can be printed via the SET card described in the User's Manual.
- 12 The BEGIN BULK card denotes the beginning of the bulk data deck. The Bulk Data Deck cards may occur in any order. Putting these cards in alphabetic sort will save NASTRAN sorting time in large problems, however.
- 13 In this problem all the parameters except slot width w_d are constant throughout the volume. The data values on the AXSLØT card will be used whenever a corresponding entry in the following cards is blank.

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- 14-20 The location of points on the slot are defined with these cards. Cards 14, 16, 18 and 20 serve a dual purpose by defining a GRIDS point identification number in field 2 and a GRIDF point identification number in field 6. The two types of points thereby are forced to have the same locations at the interface.
- 21,22 The location of points within the axisymmetric fluid cavity are described by the GRIDF card. No points are allowed to have a zero or negative radius.
- 23-31 These cards describe the elements shown in Figure 2. Each element is given a unique identification number and a list of the connected GRIDS or GRIDF points. Since the parameters ρ and B are constants, these fields are left blank so the values on the AXSLØT card will be used.
- 32,33 The EIGR card is used to define parameters for eigenvalue extraction (resonant frequencies). More than one of these cards may appear. The method to be used is selected with the METHØD= data card in the Case Control Deck (card 8). With this particular card we selected the Givens Tridiagonalization method (GIV) with a desired number of three ($N_d = 3$) output mode shapes. The modes will be normalized such that the maximum pressure is 1.0 ($NØRM=MAX$). These two cards illustrate a continuation card.
- 34 The SLBDY card defines the boundary between the slot and the central cavity. Both the density (ρ) and the number of radial slots (M) are blank so the AXSLØT defaults are used, i.e. $\rho = 1.2 \times 10^{-7}$ and $M = 4$. Only four GRIDS points are on the boundary so a continuation card is not necessary. Field 8 being blank signifies the last entry.
35. The ENDDATA card is required to denote the end of the bulk data. Any following cards will be ignored by NASTRAN.

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Table 1. Example problem data cards.

Card No.		
1	ID ACØUS, MSC	} Executive Control Cards
2	APP DISP	
3	SØL 3,0	
4	TIME 2	
5	CEND	
6	TITLE = ACØUSTIC CAVITY EXAMPLE PRØBLEM	} Case Control Data Cards
7	SUBTITLE = FIRST HARMØNIC	
8	METHØD = 11	
9	ØUTPUT	
10	PRES = ALL	
11	STRESS = ALL	
12	BEGIN BULK	

	1	2	3	4	5	6	7	8	9	10
	(AXSLØT	ρ_d	B_d	N	w_d	M_d)				
13	AXSLØT	1.2-7	21.0	1		4				
	(GRIDS	Id	r	z	w	Id _f)				
14	GRIDS	2	4.0	0.0	0.2E 01	1				
15	GRIDS	3	8.0	.0	1.0					
16	GRIDS	5	4.0	4.0	2.0	4				
17	GRIDS	6	8.0	4.0	1.0					
18	GRIDS	8	4.0	8.0	2.0	7				
19	GRIDS	9	8.0	8.0	1.0					
20	GRIDS	12	4.0	1.2+1	2.0	11				
	(GRIDF	Id	r	z)						
21	GRIDF	10	2.0	12.0						
22	GRIDF	13	2.0	1.4E1						
	(CSLØT4	Id	P_1	P_2	P_3	P_4	ρ	B	M)	
23	CSLØT4	1	2	3	6	5				
24	CSLØT4	2	5	6	9	8				
	(CSLØT3	Id	P_1	P_2	P_3		ρ	B	M)	
25	CSLØT3	3	8	9	12					
	(CAXIF2	ID	P_1	P_2			ρ	B)		
26	CAXIF2	4	1	4						
27	CAXIF2	5	4	7						
28	CAXIF2	6	7	10						
29	CAXIF2	9	10	13						

(Continued)

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Card
No.

	1	2	3	4	5	6	7	8	9	10
	(CAXIF3	Id	P ₁	P ₂	P ₃		ρ	B)		
30	CAXIF3	7	7	10	11					
31	CAXIF3	8	10	11	13					
	(EIGR	Id	Method	f ₁	f ₂	Ne	Nd	Nz		+XYZ
	(+XYZ	NØRM)								
32	EIGR	11	GIV				3			+AB
33	+AB	MAX								
	(SLBDY	ρ	M	ID1	ID2	ID3	ID4	etc.)		
34	SLBDY			12	8	5	2			
35	ENDDATA									

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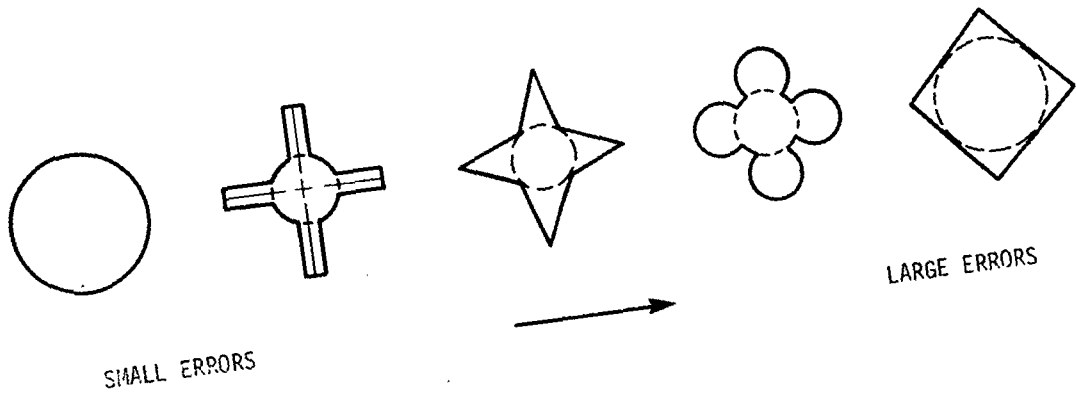
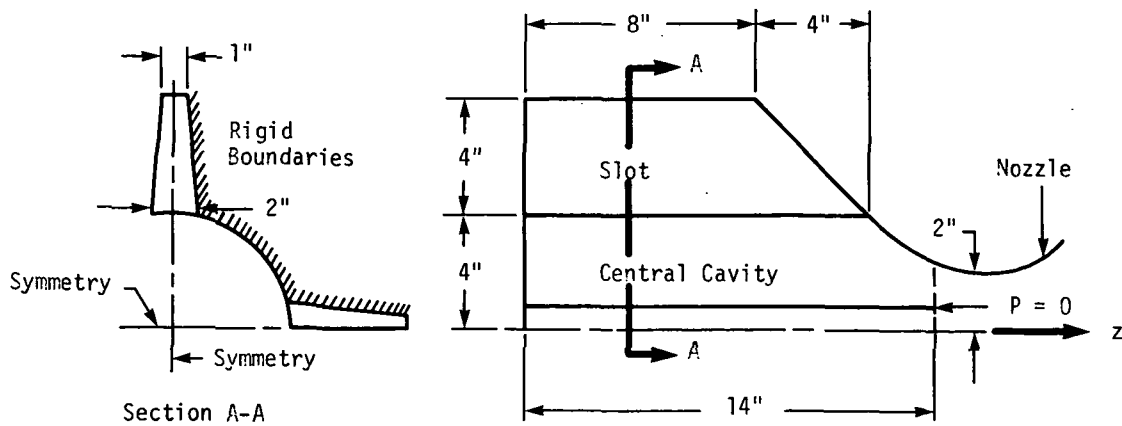


Figure 1. Modeling errors for various shapes.

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Parameters:

Density: $\rho = 1.1463 \times 10^{-7} \text{ lb-sec}^2/\text{in}^4$

Bulk Modulus: $B = \rho a^2 = \gamma RT = 20.59 \text{ lb/in}^2$

Harmonic: $N = 1$

Number of slots: $M = 4$

Note: Consistent Dimensional Units must be used.

FINITE ELEMENT MODEL:

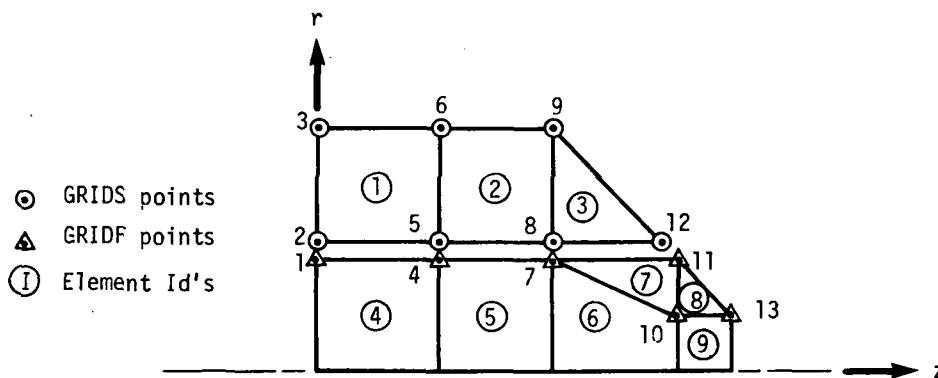


Figure 2. Description of example problem.

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1.10 MANUAL SINGLE-STAGE SUBSTRUCTURING

The theoretical basis for NASTRAN manual substructuring is given in Section 4.3 of the Theoretical Manual. The NASTRAN Substructuring technique may be used with any of the rigid formats, except Piecewise Linear Analysis. The following sections present instructions, including suggested Series N DMAP alters; for use with the rigid formats for Static Analysis and Normal Modes Analysis.

Substructure analysis, as here defined, is a procedure in which the structural model is divided into separate parts which are then processed in separate computer executions to the point where the data blocks required to join each part to the whole are generated. The subsequent operations of merging the data for the substructures and of obtaining solutions for the combined problem are performed in one or more subsequent executions, after which detailed information for each substructure is obtained by additional separate executions.

Substructure analysis by the manual substructuring technique is logically performed in at least three phases as follows:

- Phase I - Analysis of each individual substructure by NASTRAN to produce a description, in matrix terms, of its properties as seen at the boundary degrees of freedom, u_a .
- Phase II - Combination of the matrix properties from Phase I and the inclusion, if desired, of additional terms to form a "pseudostructure," which is then analyzed by NASTRAN.
- Phase III - Completion of the analysis of individual substructures using the $\{u_a\}$ vector produced in Phase II.

The NASTRAN Data Deck for each of the substructures is constructed in the same manner as for a NASTRAN analysis without substructuring. The following restrictions must be considered when forming the NASTRAN Data Deck for each of the substructures:

1. All points on boundaries between substructures which are to be joined must have their free degrees of freedom placed in the a-set.
2. The sequence of internal grid point identification numbers along the boundary between any two substructures must be the same. The internal sequence is the external sequence modified by any SEQGP cards. For example, if one substructure had boundary grid point internal identification numbers of 3, 4, 9, 27, and 31, the adjoining substructure could have a corresponding set of internal grid point identification numbers of 7, 11, 21, 22, and 41, but not 7, 11, 22, 21, and 41. This restriction is automatically satisfied if the same grid point numbers, without SEQGP cards, are used on the boundaries for connected substructures.

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3. The displacement coordinate system for each group of connected grid points on the boundaries between substructures must be the same.
4. Elements located on the boundary may be placed in either adjacent substructure.
5. The loads applied to boundary points may be arbitrarily distributed between the adjoining substructures. Care should be exercised not to duplicate the loads by placing the entire load on each substructure.
6. The constrained stiffness matrix, $[K_{00}]$, for each substructure must be nonsingular. This requirement is automatically satisfied in most cases, since usually there are enough degrees of freedom on the boundary of the substructure to account for its rigid body motions. In exceptional cases, such as when the substructure is a hinged appendage, it may be necessary for the user to assign additional degrees of freedom to u_a , rather than u_0 .

Although the following discussion is limited to single-stage substructuring, there is no inherent restriction on the use of multi-stage substructures in NASTRAN. In multi-stage substructuring, some of the substructures are precombined in Phase II to form intermediate substructures. The final combination in Phase II then consists of joining two or more intermediate substructures. This procedure will be useful if there are several substructures in the model, and changes are made in only one or a few substructures. In this case, the amount of effort and computer time required for changes in the model can be substantially reduced if the unchanged substructures are initially combined into a single intermediate substructure.

1.10.1 Basic Manual Substructure Analysis

Basic manual substructure analysis will be described with reference to the simple beam structure shown in Figure 1. The beam is arbitrarily separated into two substructures, referred to as substructure 1 and substructure 2, with a single boundary point being located at grid point 3. The beam is supported at grid points 1 and 6. No loads are applied to substructure 1. A single load is applied to substructure 2 at grid point 4, and a single load is applied at the boundary to grid point 3.

The complete NASTRAN Data Decks for all three phases of a substructure analysis for the beam shown in Figure 1 will be presented with comments for each card. The integers in the left-hand column will be used to relate the discussion to the cards in the NASTRAN Data Deck.

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The following data deck is used for the Phase I of substructure 1:

```

101 ID          PHASE ONE $ SUBSTRUCTURE 1
102 TIME        2
103 CHPNT       YES
104 APP         DISP
105 SOL         1,9
106 ALTER       100
107 JUMP        LBL7 $
108 ALTER       118
109 FBS         L00,U00,P0/U00V $
110 CHPNT       U00V $
111 OUTPUT1     E1,KLL,PL,,//C,N,-1/C,N,0/C,N,USERTP1 $
112 ALTER       119, 164
113 ENDALTER
114 CEND
115 TITLE = PHASE ONE - SUBSTRUCTURE 1
116 SPC = 101
117 BEGIN BULK
118 ASET         3          126
119 CBAR         1          10          1          2          1.0          1
120 CBAR         2          10          2          3          1.0          1
121 DMI          E1          0          2          1          1          3          1
122 DMI          E1          1          1          1.0          1.0          1.0
123 GRID         1                                345
124 GRID         2                                240.          345
125 GRID         3                                480.          345
126 MAT1         11          30.+6
127 PBAR         10          11          60.          500.
128 SPC          101          1          12
129 ENDDATA

```

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Comments are as follows:

- 101 ID card is first card of NASTRAN Data Deck.
- 102 TIME card is required in Executive Control Deck.
- 103 This run will be checkpointed, so that a restart can be made for Phase III. The user must arrange to have a physical tape mounted for the New Problem Tape (NPTP).
- 104 One of the rigid formats will be used for this problem.
- 105 Rigid Format 1 (Series N), Static Analysis, will be used for this problem without property optimization.
- 106 Insert the following statement after DMAP statement No. 100.
- 107 Jump around the Rigid Body Matrix Generator modules. The solution for $\{u_a\}$ will be performed in Phase II.
- 108 Insert the following three statements after DMAP statement No. 118.
- 109 Use the module FBS to solve for $\{u_o^0\}$ the displacement of the o-set points relative to the a-set points.
- 110 Write displacement vector $U\emptyset\emptyset V$ on the New Problem Tape.
- 111 Use the module $\emptyset UTPUT1$ to write the DMI matrix given on cards 121 and 122, along with the stiffness matrix KLL, and the load vector PL on User Tape 1 (USERTP1). The user must arrange to have a physical tape mounted for User Tape 1 (INPT). The details of the call for DMAP module $\emptyset UTPUT1$ and other DMAP information are given in Section 5.
- 112 Delete the data recovery modules.
- 113 End of the ALTER package.
- 114 Last card of Executive Control Deck.
- 115 Title information for Phase I substructure 1 printed output.
- 116 Select single-point constraint set 101.
- 117 Indicates the beginning of the Bulk Data Deck.
- 118 Defines grid point 3 as a boundary point between substructures.
- 119 } Connection cards defining bar elements in substructure 1.
- 120 }
- 121 } Direct Matrix Input cards that define the partitioning vector for use in Phase II. The
- 122 } entries on these cards are discussed below.
- 123 }
- 124 } These cards define the grid points in substructure 1.
- 125 }

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- 126 Defines the material for the elements in substructure 1.
- 127 Defines the properties of the elements in substructure 1.
- 128 Defines single-point constraint set 101. Components 1 and 2 are constrained at grid point 1 in substructure 1.
- 129 End of NASTRAN Data Deck.

It should be noted that no output has been requested in the Case Control Deck for substructure 1. If the user wishes to have a plot of the undeformed structure for checking the model, a Plot Package can be inserted in the Case Control Deck in the usual way, as described in Section 4.2.

The partitioning matrix gives the relationship between the internal indices associated with the a-set matrices generated in Phase I and the external grid point component definition given on the grid cards that are input to Phase I as modified by any SEQGP cards. The same internal indices in Phase I for the a-set are redefined in Phase II as the indices for the g-set. The word pseudostructure is associated with the g-size matrices used in Phase II.

The partitioning matrix for the problem under consideration is given as follows:

PARTITIONING MATRIX

<u>Internal Index</u>	<u>External Grid-Component</u>	
	<u>Substructure 1</u>	<u>Substructure 2</u>
1	3-1	3-1
2	3-2	3-2
3	3-6	3-6

The procedure for constructing a partitioning matrix is as follows:

1. Select any one of the substructures and list the components of the a-set in sequence by grid point and component number as modified by any SEQGP cards (internal sequence). These are the nonzero entries in the partitioning vector for the first substructure.
2. Build the second column of the partitioning matrix by selecting any connected substructure and entering the connected components in the same row as the associated components in the first substructure.
3. Enter all unconnected a-set components in unoccupied rows of the partitioning matrix according to their internal sequence numbers. Unconnected members of the a-set having

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- internal sequence numbers in the range of the connected components will create new intermediate rows in the previously formed columns of the matrix.
4. Build the remaining columns of the partitioning matrix, one for each substructure, by following a similar procedure for all remaining substructures. In each case, first enter all components that are connected to the previously selected substructure or substructures, followed by the remaining unconnected components in their internal sequence.
 5. The rows of the partitioning matrix are associated with the sequence of the internal indices for the scalar points in the pseudostructure. Any sequential set of integers may be used to identify these scalar points in Phase II.
 6. The columns of the partitioning matrix (one vector for each substructure) are input with Direct Matrix Input (DMI) cards. The input matrix contains real 1's in all locations in the partitioning matrix having grid point-component entries. See Section 2.4 for DMI card format.

The DMI cards (121 and 122) in the sample problem give the name E1 to the partitioning vector for substructure 1. The first card defines the partitioning vector as being rectangular and consisting of real single-precision entries. The next to the last entry on the first card indicates there are three rows in the g-set matrices input to Phase II. The second integer 1 on the second card indicates that the first internal index is associated with one of the components in substructure 1; in this case, grid point 3, component 1. The three real 1.0's indicate the first three internal indices are associated with components in substructure 1; in this case, grid point 3, components 1, 2, and 6. In this particular case, only the initial two steps are required to construct the partitioning matrix and the partitioning vector for substructure 2 will be identical to that for substructure 1. This results from the fact that the single boundary point in this problem is a part of both substructures.

The partitioning vectors are not needed until Phase II. They were arbitrarily input to Phase I so they could be included on the User Tape, along with the output matrices from Phase I.

The NASTRAN Data Deck for substructure 2 is given below. For identification purposes, the cards are arbitrarily numbered beginning with 150.

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```

150 ID      PHASE ONE $ SUBSTRUCTURE 2
151 TIME    2
152 CHKPNT  YES
153 APP      DISP
154 SOL      1, 9
155 ALTER    100
156 JUMP     LBL7 $
157 ALTER    118
158 FBS      L00,U00,P0/U00V $
159 CHKPNT   U00V $
160 OUTPUT1  E2,KLL,PL,,//C,N,-1/C,N,0/C,N,USERTP2 $
161 ALTER    119, 164
162 ENDALTER
163 CEND
164 TITLE = PHASE ONE - SUBSTRUCTURE 2
165 SPC = 201
166 LOAD = 202
167 BEGIN BULK
168 ASET      . 3      126
169 CBAR      3      10      3      4      1.0      1
170 CBAR      4      10      4      5      1.0      1
171 CBAR      5      10      5      6      1.0      1
172 DMI       E2      0      2      1      1      3      1
173 DMI       E2      1      1      1.0      1.0      1.0
174 FORCE      202      3      1000.      -1.0
175 FORCE      202      4      1000.      -1.0
176 GRID      3      480.      345
177 GRID      4      720.      345
178 GRID      5      960.      345
179 GRID      6      1200.      345
180 MAT1      11      30.+6
181 PBAR      10      11      60.      500.

```

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182 SPC 201 6 2

183 ENDDATA

Comments are given only for those cards which are different from those given in substructure 1.

150 The ID card contains the comment following the dollar sign indicating the deck is for substructure 2.

160 The partitioning vector for substructure 2 is written on User Tape 2 and is named E2. The user must arrange to mount a second physical tape for INPT. It is possible to change the OUTPUT1 statement and write the results for substructure 2 on the same tape as for substructure 1, if desired.

164 The printed output will indicate this run is for substructure 2.

165 Selects single-point constraint set 201.

166 Selects load set 202.

172 } Other than the name E2, the partitioning vector is identical to that for substructure 1.
173 }

174 } Defines the external loads in load set 202. The load applied to grid point 3 has
175 } arbitrarily been placed in substructure 2.

182 Defines single-point constraint set 201 at grid point 6, component 2.

The Phase II operations are concerned with merging the a-set matrices generated in Phase I which define the g-size pseudostructure in Phase II. The NASTRAN Data Deck for Phase II is given below. The cards are arbitrarily numbered beginning with 201.

201 ID PHASE TWO

202 TIME 2

203 APP DISP

204 SOL 1,9

205 ALTER 1

206 PARAM //C,N,NOP/V,N,TRUE=-1 \$

207 ALTER 7,22

208 ALTER 25,64

209 INPUT1 /E01,KGG01,PG01,.,/C,N,-1/C,N,1/C,N,USERTP1 \$

210 MERGE, ,,,KGG01,E01,/KGGT01 \$

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```

211 ADD      KGG,KGGT01/KT01 $
212 EQUIV    KT01,KGG/TRUE $
213 MERGE,   ,PG01,,,E01/PGT01/C,N,1 $
214 ADD      PGT,PGT01/PT01 $
215 EQUIV    PT01,PGT/TRUE $
216 INPUTT1  /E02,KGG02,PG02,,/C,N,-1/C,N,2/C,N,USERTP2 $
217 MERGE,   ,,,KGG02,E02,/KGGT02 $
218 ADD      KGG,KGGT02/KT02 $
219 EQUIV    KT02,KGG/TRUE $
220 MERGE,   ,PG02,,,E02/PGT02/C,N,1 $
221 ADD      PGT,PGT02/PT02 $
222 EQUIV    PT02,PGT/TRUE $
223 ALTER    73,78
224 ALTER    111,111
225 SSG1     SLT,BGPD,T,CSTM,SIL,,MPT,,EDT,,CASECC,DIT/PG/V,N,LUSET/V,N,NSKIP $
226 ADD      PGT,PG/PGX $
227 EQUIV    PGX,PG/TRUE $
228 ALTER    137,141
229 ØUTPUT1, ,,,,//C,N,-1/C,N,0/C,N,USERTP3 $
230 PARTN    UGV,,E01/,ULV01,,/C,N,1 $
231 ØUTPUT1  ULV01,,,//C,N,0/C,N,0/C,N,USERTP3 $
232 PARTN    UGV,,E02/,ULV02,,/C,N,1 $
233 ØUTPUT1  ULV02,,,//C,N,0/C,N,0/C,N,USERTP3 $
234 SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPD,T,PGG,QG,UGV,,/ØPG1,ØQG1,ØUGV1,,,/C,N,STATICS $
235 ØFP      ØUGV1,ØPG1,ØQG1,,,/V,N,CARDNØ $
236 ALTER    154,156
237 ALTER    158,164
238 ALTER    168,169
      ALTER    172,173
239 ENDALTER
240 CEND
241 TITLE = PHASE TWO
242 BEGIN BULK

```

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243	DMI	KGG	0	6	1	2	3	3
244	DMI	KGG	1	1	0.0			
245	DMI	PGT	0	2	1	2	3	1
246	DMI	PGT	1	1	0.0			
247	SPØINT	1	THRU	3				
248	ENDDATA							

Comments for each of the cards are as follows:

- 201 The ID card is the first card of the NASTRAN Data Deck.
- 202 The TIME card is required in the Executive Control Deck.
- 203 One of the rigid formats will be used to solve this problem.
- 204 Rigid Format 1 (Series N), Static Analysis, will be used for this problem.
- 205 Insert the following statement after DMAP statement No. 1.
- 206 Define the parameter TRUE = -1.
- 207 Delete the DMAP statements associated with the preparation of the Element Connection Table and structure plots.
- 208 Delete the DMAP statements associated with matrix assembly.
- 209 Insert the DMAP module.INPUTT1 to read the partitioning vector, the stiffness matrix, and the load vector from User Tape 1. These matrices have been renamed E01, KGG01, and PG01, respectively. The user must arrange to have the tape mounted that was prepared during the Phase I run of substructure 1. This tape should be designated as INP1.
- 210 Insert the module MERGE to change the a-set size of the stiffness matrix from Phase I to g-size for Phase II, and designate the output as KGGT01. In this particular case, no change will take place, since the a-size from Phase I is the same as the g-size in Phase II.
- 211 Insert the module ADD to add the null matrix KGG, defined in the Bulk Data Deck, to KGGT01, and designate the output as KT01.
- 212 Insert the module EQUIV to equivalence KT01 to KGG.
- 213 Insert the module MERGE to change the a-size of the load vector from Phase I to g size for Phase II, and designate the output as PGT01. In this case, no change in size will take place.
- 214 Insert the module ADD to add the null matrix PGT, defined in the Bulk Data Deck, to PGT01, and designate the output as PT01.

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- 215 Insert the module EQUIV to equivalence PT01 to PGT.
- 216 Insert the module INPUT1 to read the partitioning vector, the stiffness matrix, and the load vector from User Tape 2. These matrices which were generated for substructure 2 in Phase I are redesignated as E02, KGG02, and PG02, respectively.
- 217 Insert the module MERGE to change the stiffness matrix for substructure 2 from a-size in Phase I to g-size in Phase II and designate the output as KGGT02.
- 218 Insert the module ADD to add the stiffness matrix for substructure 2 to the stiffness matrix for substructure 1, and designate the output as KT02.
- 219 Insert module EQUIV to equivalence KT02 to KGG. The matrix KGG now represents the stiffness matrix for the pseudostructure, and will be used for input to Phase II.
- 220 Insert the module MERGE to change the load vector from a-size in Phase I to g-size in Phase II.
- 221 Insert the module ADD to add the loads applied to substructure 2 to the load vector for substructure 1, and designate the output as PT02.
- 222 Insert the module EQUIV to equivalence PT02 to PGT.
- 223 Delete the DMAP statements associated with the Grid Point Singularity Processor.
- 224 Delete the module SSG1 as given in Rigid Format 1.
- 225 Insert the module SSG1 with the calling sequence modified to remove parts not associated with directly applied loads. Since, for this particular problem, all loads were applied in Phase I, there will be no output from SSG1.
- 226 Insert the module ADD to combine the load vector from Phase II with the load vectors generated in Phase I, and designate the output as PGX.
- 227 Insert the module EQUIV to equivalence PGX to PG. The data block PG now includes all loads from both Phase I and Phase II, and will be used as input to Phase III.
- 228 Remove SDR2 and ØFP as given in Rigid Format 1.
- 229 Insert the module ØUTPUT1 to rewind User Tape 3 and place the label USERTP3 on this tape. The user must arrange to have a physical tape mounted and designated as INPT.
- 230 Insert the module PARTN to separate that part of the solution vector UGV associated with substructure 1, and designate the output as ULV01.
- 231 Insert the module ØUTPUT1 to write the partition of the solution vector associated with substructure 1 on User Tape 3.
- 232 Insert the module PARTN to separate that part of the solution vector associated with substructure 2, and designate the output as ULV02.

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- 233 Insert the module ØUTPUT1 to write that part of the solution vector associated with substructure 2 on User Tape 3. This will place the solution vectors for both substructures on User Tape 3. A second tape could be used for the solution vector for substructure 2 by changing the DMAP statement for ØUTPUT1.
- 234 Insert the module SDR2 with the calling sequence modified to remove those parts associated with element output.
- 235 Insert the module ØFP with the calling sequence modified to remove those parts associated with element output.
- 236 Remove ØFP as given in Rigid Format 1.
- 237 Remove the DMAP statements associated with the preparation of the deformed structure plots.
- 238 Remove the statements associated with ERRØR2 and ERRØR4.
- 239 End of ALTER package.
- 240 End of Executive Control Deck.
- 241 Title information for Phase II printed output.
- 242 Beginning of the Bulk Data Deck.
- 243 }
244 } DMI cards used to define the null matrix KGG.
- 245 }
246 } DMI cards used to define the null matrix PGT.
- 247 Definition of the three scalar points for the pseudostructure.
- 248 End of NASTRAN Data Deck.

Although the data deck shown above is prepared for two substructures, it was constructed in such a manner that it could be easily extended to more than two substructures. If there are more than two substructures, cards similar to 216 to 222, 232, and 233 need to be added to the NASTRAN data deck for each additional substructure.

The final part of a substructure analysis is to perform data recovery for each substructure of interest. These runs are made as a restart of the Phase I runs. Any of the normal rigid format output can be requested, including both undeformed and deformed structure plots. All of the output will be in terms of the elements and grid points defined in the Phase I Bulk Data Decks. The NASTRAN Data Deck for the Phase III analysis of substructure 1 is given as follows:

```
301 ID          PHASE THREE $ SUBSTRUCTURE 1
```


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```

302 TIME      2
303 APP       DISP
304 SOL       1,9
305 ALTER     23,125
306 INPUTT1   /,,,/C,N,-1/C,N,0/C,N,USERTP3 $
307 INPUTT1   /ULV,,,/C,N,0 $
308 ALTER     128,133
309 ALTER     165,176
310 ENDALTER
311 (Include Restart Dictionary from Phase I)
312 CEND
313 TITLE = PHASE THREE - SUBSTRUCTURE 1
314 DISP = ALL
315 ELFORCE = ALL
316 LOAD = ALL
317 SPCFORCE = ALL
318 BEGIN BULK
319 (No Bulk Data)
320 ENDDATA

```

Comments for each of the cards are as follows:

```

301 ID card is first card of the NASTRAN Data Deck.
302 TIME card is required in the Executive Control Deck.
303 One of the rigid formats will be used for this problem.
304 Rigid Format 1 (Series N), Static Analysis, will be used for this problem.
305 Delete all parts of the rigid format, except the data recovery modules.
306 Insert module INPUTT1 to rewind and check the label on User Tape 3. The user must
    arrange to have User Tape 3 mounted and designated as INPT.
307 Insert module INPUTT1 to read the solution vector for substructure 1 from User Tape 3.
    The solution vector is designated as ULV for input to module SDR1.
308 } Remove additional DMAP statements not associated with data recovery operations.
309 }

```

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- 310 End of ALTER package.
- 311 Insert the Restart Dictionary punched during the Phase I run of substructure 1.
- 312 End of Executive Control Deck.
- 313 Title information for printed output for Phase III.
- 314 Request printed output for all displacements of substructure 1.
- 315 Request printed output of forces for all elements in substructure 1.
- 316 Request printed output of the load vector for substructure 1. In this particular case, no output will result because no loads were applied to substructure 1.
- 317 Request printed output for all nonzero single-point forces of constraint on substructure 1.
- 318 Beginning of Bulk Data Deck.
- 319 No bulk data cards should be included in the Phase III run. However, the BEGIN BULK and ENDDATA cards must be present.
- 320 End of NASTRAN Data Deck.

The NASTRAN data deck for the Phase III analysis of substructure 2 is given below. Comments are restricted to cards that are different from those presented for the Phase III run of substructure 1.

```
350 ID          PHASE THREE $ SUBSTRUCTURE 2
351 TIME        2
352 APP         DISP
353 SOL         1,9
354 ALTER       23,125
355 INPUTT1     /,,,/C,N,-1/C,N,0/C,N,USERTP3 $
356 INPUTT1     /ULV,,,/C,N,1 $
357 ALTER       128,133
358 ALTER       165,176
359 ENDALTER
360      (Include Restart Dictionary from Phase I)
361 CEND
362 TITLE = PHASE THREE - SUBSTRUCTURE 2
363 DISP = ALL
364 ELFORCE = ALL
```

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```
365  ØLOAD = ALL
366  SPCFORCE = ALL
367  BEGIN BULK
368      (No Bulk Data)
369  ENDDATA
```

Comments are as follows:

```
350  The comment following the dollar sign indicates this analysis is for substructure 2.
355  Insert module INPUTT1 to rewind User Tape 3. The user must arrange to mount User Tape 3,
      if it is not already mounted as a result of the previous run on substructure 1.
356  Insert module INPUTT1 to skip over the solution vector for substructure 1 on User Tape 3,
      and read the solution vector for substructure 2.
365  The request for printed output of the load vectors will show nonzero loads applied to
      grid points 3 and 4.
```

1.10.2 Loads and Boundary Conditions

The single load and the single boundary condition for the sample problem in Section 1.10.1 were introduced in Phase I. It is also possible to introduce loads and boundary conditions in Phase II. In this case, the loaded and/or constrained degrees of freedom must be included in the a-set for Phase I, so they will be a part of the pseudostructure in Phase II. Loads are applied to the pseudostructure in Phase II with the SLØAD card. This limits the type of load that can be applied in Phase II to directly applied loads. Other loading conditions depending on element properties or connection data, such as thermal loads, gravity loads, and pressure loads, must be applied in Phase I. Loads may be introduced in both Phases I and II, as the suggested DMAP sequence will add contributions to the load vector from both phases. The lack of generality for the application of loads in Phase II will often dictate that static loads be applied in Phase I.

The loads and boundary conditions for the sample problem can be applied in Phase II if the following modifications are made to the NASTRAN Data Decks presented in Section 1.10.1.

1. Remove card 116, SPC set selection for Phase I substructure 1.
2. Replace card 118 as shown below to redefine the a-set for substructure 1.

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3. Replace cards 121 and 122 with cards 121, 122, and 122a shown below to redefine the partitioning vectors for substructure 1.
4. Card 128 is not required, SPC set definition for substructure 1.
5. Remove cards 165 and 166, SPC and load set selection for Phase I, substructure 2.
6. Replace card 168 as shown below to redefine the a-set for substructure 2.
7. Replace cards 172 and 173 with cards 172, 173, and 173a shown below to redefine the partitioning vectors for substructure 2.
8. Cards 174, 175, and 182 are not required, load definition and SPC definition for substructure 2.
9. Insert cards 241a and 241b as shown below after card 241 in the Case Control Deck for Phase II for the selection of the boundary conditions and loading condition.
10. Replace cards 243 and 245 as shown below to conform to new size for pseudostructure.
11. Insert the cards 246a and 246b as shown below in the Bulk Data Deck for Phase II for definition of the loading condition and boundary condition.
12. Replace card 247 as shown below to modify the definition of the pseudostructure to contain 12 scalar points.

118	ASET1	126	1	3						
121	DMI	E1	0	2	1	1		12	1	
122	DMI	E1	1	1	1.0	1.0	1.0	1.0	1.0	+E11
122a	+E11	E1	1.0							
168	ASET1	126	3	4	6					
172	DMI	E2	0	2	1	1		12	1	
173	DMI	E2	1	4	1.0	1.0	1.0	1.0	1.0	+E21
173a	+E21	E2	1.0	1.0	1.0	1.0				
241a SPC = 201										
241b LOAD = 202										
243	DMI	KGG	0	6	1	2		12	12	
245	DMI	PGT	0	2	1	2		12	1	
246a	SLLOAD	202	5	1000.	8	1000.				
246b	SPC1	201		1	2	11				
247	SPPOINT	1	THRU	12						

The modified partitioning matrix with grid points 1, 3, 4, and 6 in the a-set is shown below.

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PARTITIONING MATRIX

<u>Internal Index</u>	<u>External Grid-Component</u>	
	<u>Substructure 1</u>	<u>Substructure 2</u>
1	1-1	
2	1-2	
3	1-6	
4	3-1	3-1
5	3-2	3-2
6	3-6	3-6
7		4-1
8		4-2
9		4-6
10		6-1
11		6-2
12		6-6

The modified partitioning matrix contains twelve scalar points, with six in substructure 1, nine in substructure 2, and three common to both substructures. The loads are now located at scalar points 5 and 8, as indicated on card 246a. The single-point constraints are located at scalar points 1, 2, and 11, as indicated on card 246b. The modified partitioning vector for substructure 1 indicates there are twelve degrees of freedom in the pseudostructure, and that, beginning with the first scalar point, there are six scalar points associated with substructure 1. The modified partitioning vector for substructure 2 indicates the first entry is associated with scalar point 4, and that there are a total of nine scalar points associated with substructure 2.

If multiple loading conditions are used in the solution, the subcase structure must be established in Phase I. In order to perform the matrix operations in Phase II, the same case control structure must be used for all substructures. This means that the same number of subcases must be defined for each substructure, even though some of the subcases will not contain a load selection or any other entries. NASTRAN will generate a null column in the load matrix for all subcases for which no load set is selected. If any loads are applied in Phase II, the same subcase structure must be used in Phase II. In any event, the subcase structure established in Phase I must be used in Phase III. The contents of each subcase in Phase III will relate to

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output selections, rather than load and boundary condition selections.

Consider adding two additional loading conditions to the sample problem in Section 1.10.1. If one additional loading condition were applied to substructure 1, identified as 202, and one additional loading to substructure 2, identified as 203, the subcase structure established in Phase I would appear as follows:

<u>Substructure 1</u>	<u>Substructure 2</u>
SPC = 101	SPC = 201
SUBCASE 1	SUBCASE 1
	LØAD = 201
SUBCASE 2	SUBCASE 2
LØAD = 202	
SUBCASE 3	SUBCASE 3
	LØAD = 203

Load case 202 would have to be defined with some form of static loading in the Bulk Data Deck for Phase I of substructure 1. In addition, load set 203 would have to be defined with some form of static loading in the Bulk Data Deck for Phase I of substructure 2.

The suggested DMAP sequence for the sample problem in Section 1.10.1 will not support multiple boundary conditions in Phase I. If multiple boundary conditions are introduced in Phase I, it is necessary to generate a separate partitioning vector for use in Phase II for each of the unique boundary conditions. In some sense, this results in the definition of a number of separate problems equal to the number of unique boundary conditions. Although a DMAP sequence could be developed to support multiple boundary conditions in Phase I, it is not recommended that multiple boundary conditions be introduced into Phase I.

Multiple boundary conditions may be introduced in Phase II without any difficulty. However, in order to handle the internal looping for each boundary condition, it is more convenient if the loads are also introduced in Phase II. As indicated earlier, the introduction of loads in Phase II does limit the manner in which the static loads can be defined. If the loads and boundary conditions are introduced in Phase II, all of the case control options for combining subcases, including symmetry combinations, may be used in the usual manner.

MANUAL SINGLE-STAGE SUBSTRUCTURING

It is possible to introduce the loads in Phase I and multiple boundary conditions in Phase II. However, provision must be made to generate all loading conditions in Phase I, which will automatically take place if one subcase is defined for each loading condition and no boundary conditions are mentioned in the Phase I Case Control Deck. It is then necessary in Phase II to partition out the proper columns of the loading matrix for each loop or boundary condition in Phase II. This requires that the user construct the proper partitioning vector for each boundary condition. Also, appropriate modifications would have to be made to the suggested DMAP sequence for Phase II.

1.10.3 Dynamic Analysis

Substructuring for dynamic analysis is performed in much the same way as that for static analysis. A suggested NASTRAN Data Deck for use in Phase I of a Normal Modes Analysis (Rigid Format 3) is shown below:

```
ID          PHASE ONE $ NORMAL MODES
TIME        2
CHKPNT      YES
APP         DISP
SOL         3,0
ALTER       86,126
OUTPUT1     E10,KAA,MAA,,//C,N,-1/C,N,0/C,N,USERTP1 $
ENDALTER
CEND

      (Case Control Deck)
BEGIN BULK
      (Bulk Data Deck)
ENDDATA
```

Note that the OUTPUT1 module writes the mass matrix, as well as the stiffness matrix and partitioning vector on User Tape 1. The Case Control Deck is similar to the Phase I deck for static analysis. It must include a constraint selection if the boundary conditions are applied in Phase I. The Bulk Data Deck is also similar to that used in Phase I for static analysis. In general, it includes all the cards associated with the definition of the model and the DMI cards for the definition of the partitioning vector. It will also include cards for the definition of

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the a-set and other constraint cards if the boundary conditions are applied in Phase I. As in static analysis, one such deck must be prepared for each substructure.

The suggested NASTRAN Data Deck for Phase II of Normal Modes Analysis with two substructures is shown below:

```

ID          PHASE TWO $ NORMAL MODES
TIME        2
APP         DISP
SOL         3,0
ALTER       1
PARAM       //C,N,NOP/V,N,TRUE=-1 $
ALTER       6,49
INPUTT1     /E01,KGG01,MGG01,,/C,N,-1/C,N,1/C,N,USERTP1 $
MERGE,      ,,,KGG01,E01,/KGGT01 $
ADD         KGG,KGGT01/KT01 $
EQUIV       KT01,KGG/TRUE $
MERGE,      ,,,MGG01,E01,/MGGT01 $
ADD         MGG,MGGT01/MT01 $
EQUIV       MT01,MGG/TRUE $
INPUTT1     /E02,KGG02,MGG02,,/C,N,-1/C,N,2/C,N,USERTP2 $
MERGE,      ,,,KGG02,E02,/KGGT02 $
ADD         KGG,KGGT02/KT02 $
EQUIV       KT02,KGG/TRUE $
MERGE,      ,,,MGG02,E02,/MGGT02 $
ADD         MGG,MGGT02/MT02 $
EQUIV       MT02,MGG/TRUE $
ALTER       57,62
ALTER       119,120
OUTPUT1     LAMA,,,,//C,N,-1/C,N,0/C,N,USERTP3 $
PARTN       PHIG,,E01/PHIA01,,/C,N,1 $
OUTPUT1     PHIA01,,,,//C,N,0/C,N,0/C,N,USERTP3 $
PARTN       PHIG,,E02/PHIA02,,/C,N,1 $

```


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```

ØUTPUT1  PHIA02,,,,//C,N,O/C,N,O/C,N,USERTP3 $
SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,QG,PHIG,,/,ØQG1,ØPHIG,,,/C,N,REIG $
ØFP      ØPHIG,ØQG1,,,,//V,N,CARDNØ $
ALTER    122,126
ALTER    128,129
ENDALTER
CEND

```

(Case Control Deck)

BEGIN BULK

(Bulk Data Deck)

ENDDATA

The Phase II NASTRAN Data Deck for Normal Modes Analysis is similar to that used for Static Analysis. The following comments are related to differences in the two decks:

1. Since there are no loads associated with a normal modes analysis, the module GP3 is not executed.
2. The same operations are performed on the mass matrix as are performed for the stiffness matrix.
3. The data block LAMA (Eigenvalue Summary) is written as the first data block on User Tape 3. This is followed by the appropriate partitions of the eigenvectors for each of the substructures.
4. The Case Control Deck must include a method selection for eigenvalue extraction.
5. The Bulk Data Deck is similar to that used in static analysis, except that a null matrix must be defined for the mass matrix, instead of the load matrix, and an EIGR card must be included.

In dynamic analysis, the a-set will include, in addition to all points on the boundary of the substructure, a number of points within each substructure sufficient to define the dynamic response. Since all active degrees of freedom along interior boundaries must be included in u_a , the a-set will contain more degrees of freedom than are needed in dynamic analysis, with a large resulting inefficiency for a very small gain in accuracy. This is a serious consideration because, due to the high density of K_{aa} , the time to perform most of the significant matrix operations in Phase II increases nearly as the cube of the number of degrees of freedom in u_a . The situation can be greatly improved by a second stiffness reduction in Phase II, in which u_a is partitioned into a set, u_c , that will be retained in dynamic analysis, and a set, u_b , that will be eliminated. The u_b set includes the excess degrees of freedom on the interior boundaries.

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The second stiffness reduction in Phase II is defined by listing the members of the u_b set that will be eliminated on OMIT cards. These omitted degrees of freedom must reference the scalar points associated with the pseudostructure.

In Phase III for dynamics, each NASTRAN substructure is restarted with the partition of the Phase II solution vector, or eigenvector, for each substructure. All normal data reduction procedures may then be applied. In dynamic analysis, Phase III can be omitted if output requests are restricted to the response quantities for the scalar points of the pseudostructure. In this case, the output and partition modules can be omitted from the Phase II runs, as their only purpose is to serve as input for the Phase III runs.

If output is desired for dependent response quantities or element stresses and forces, a Phase III run must be made for each substructure of interest. The suggested NASTRAN Data Deck is given below for a Phase III dynamics run:

```
ID          PHASE THREE $ NORMAL MODES
TIME        2
APP         DISP
SOL         3,0
ALTER       22,107
INPUTT1     /LAMA,,,/C,N,-1/C,N,0/C,N,USERTP3 $
INPUTT1     /PHIA,,,/C,N,0 $
ALTER       127,134
ENDALTER
      (Include Restart Dictionary from Phase I)
CEND
      (Case Control Deck)
BEGIN BULK
      (No Bulk Data)
ENDDATA
```

The Phase III data deck for Normal Modes Analysis is similar to that used for Static Analysis. The first reference to module INPUTT1 is to read the data block LAMA, which is the first data block on User Tape 3. The second reference to INPUTT1 is to read the proper partition of the eigenvectors. The zero parameter at the end of the statement should be

incremented one for each substructure in order to point to the proper eigenvector partition.

Substructuring may be used with any of the other dynamics rigid formats. The NASTRAN Data Decks will be similar to those used for Normal Modes Analysis. All dynamic loads must be applied in Phase II. If the SUPORT card is needed to define free body motions for the structure as a whole, it must be included in Phase II.

1.10.4 DMAP Loops for Phase II

The suggested DMAP sequences for the substructure example in Section 1.10.1 uses repeated blocks of code for each substructure. Cards 209 through 215 are associated with input for substructure 1. Cards 216 through 222 perform the same operations for substructure 2. Likewise, cards 230 and 231 are associated with output for substructure 1, and cards 232 and 233 are associated with output for substructure 2. If a large number of substructures are used, it is more convenient to use a DMAP loop, rather than repeating blocks of code. DMAP loops are constructed by placing a LABEL statement at the beginning of the loop and an REPT statement at the end of the loop. The number of times the REPT statement must be executed is set by an integer constant.

The series of statements represented by cards 209 through 222 can be replaced with the following sequence of DMAP operations:

```
PARAM    // C,N,NOP / V,N,INP=1 $
LABEL    BLØCK1 $
INPUTT1  / E,KGGA,PGA,, / C,N,-3 / V,N,INP $
MERGE,    ,,,KGGA,E, / KGGTA $
ADD      KGG,KGGTA / KTA $
EQUIV    KTA,KGG / TRUE $
MERGE,    ,PGA,,,E / PGTA / C,N,1 $
ADD      PGT,PGTA / PTA $
EQUIV    PTA,PGT / TRUE $
PARAM    // C,N,ADD / V,N,INP / V,N,INP / C,N,1 $
REPT     BLØCK1,1 $
```

The LABEL, BLØCK1, is shown at the beginning of the loop, and the REPT statement is shown at the end. The integer in the REPT statement is set to one less than the number of substructures,

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which in this case is one. The PARAM statement preceding the REPT statement is used to increment the second parameter of INPUT1 by one each time through the loop. This causes the information to be read from a different tape each time through the loop. This DMAP loop does not check the label before reading the information on the input tape. The fact that the same names are used for the matrices each time through the loop does not cause any difficulty, as the matrices are located by their position on the tape, rather than by name.

If a DMAP loop is used for the input sequence, consideration must be given to its effect on the output sequence. Since the partitioning vectors were not saved on each pass through the DMAP loop for the input sequence, it is necessary to recover this information for use in the output sequence. This might be done by rerunning INPUT1 to reread the partitioning vectors as needed, or perhaps by inserting the DMI cards for the partitioning vectors in the Bulk Data Deck for Phase II. If Phase III runs are not required, no output sequence is necessary.

1.10.5 Identical Substructures

In the case of identical substructures, the substructuring procedures can be organized to take full advantage of the repetitive parts. The substructures only have to appear identical in Phase I. The loading conditions and boundary conditions used in Phase II may be quite different for the otherwise identical substructures. The Phase I substructures must have identical geometry, including the global coordinate systems used on the boundary grid points.

Only a single Phase I run is made for each group of identical substructures. Since the identical substructures will be coupled in different ways during Phase II, a different partitioning vector must be generated for each use of the identical substructures in Phase II. These multiple partitioning vectors can be placed on the same output tape from Phase I, which also contains the single set of structural and loading matrices for the group of identical substructures.

The user may choose to make one or more Phase III runs for the members of a group of identical substructures. If the loading conditions and boundary conditions are also identical for the group of identical substructures, a single Phase III run will give all information of interest. However, if the boundary conditions and/or loading conditions are different for the various members of the group of identical substructures, it will probably be desirable to make a separate Phase III run for each of the substructures used in the complete structural model.

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The use of identical substructures not only saves time in computer runs for Phase I and perhaps for Phase III, but also substantially reduces the effort associated with the preparation of the structural model in the Bulk Data Deck. In some sense, substructuring procedures with identical substructures can be thought of as being a form of data generation. Although substructuring is usually used because of problem size, it may be desirable, in some cases, to use substructuring because of the repetitive nature of the structure, and a consequent saving in data generation effort.

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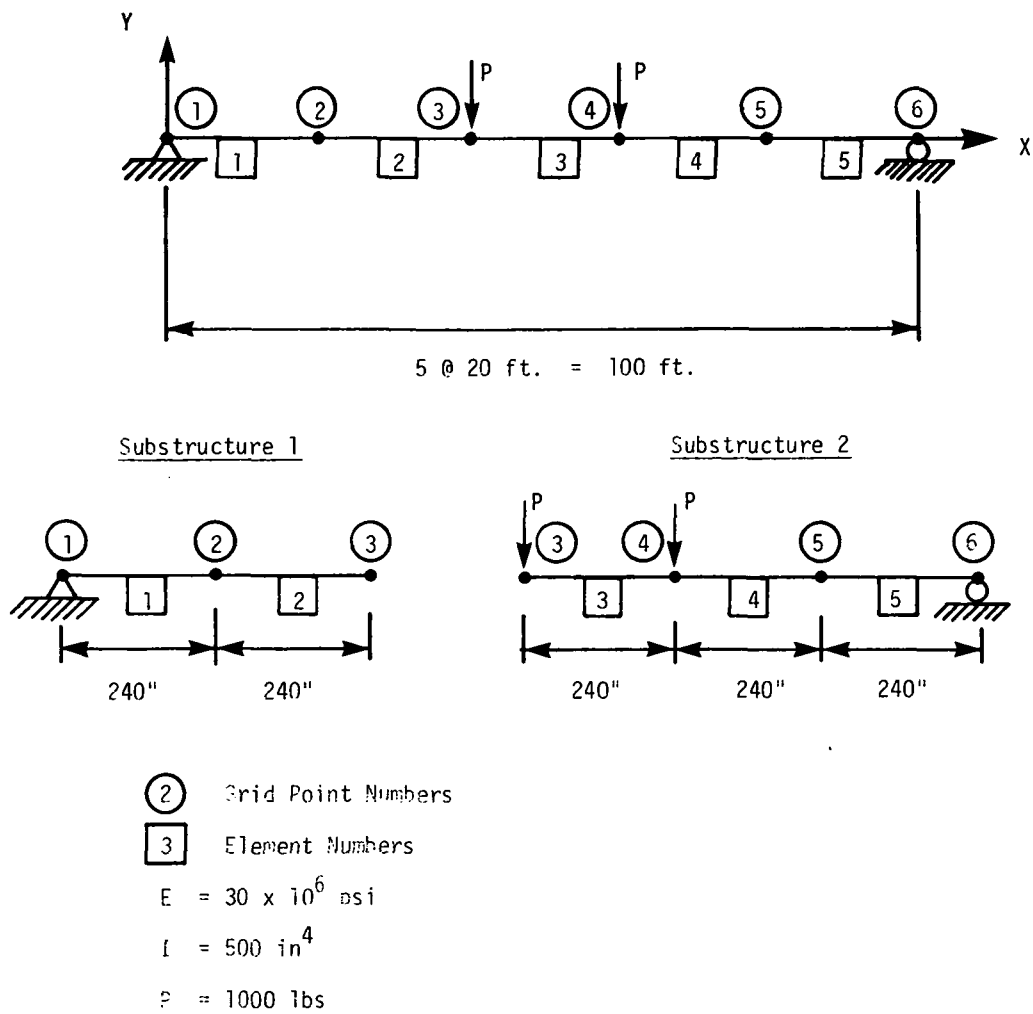


FIGURE 1. Substructure Problem

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1.11 AEROELASTIC MODELING

1.11.1 Introduction

The NASTRAN aeroelastic capability is compatible with the general structural capability. It is not designed for use with other special capabilities such as conical shell elements, hydroelastic option, and acoustic cavity analysis. The structural part of the problem will be modeled as described in other sections of this manual. This section deals with the new data, which is entirely aerodynamic, and with the connection between structural and aerodynamic elements.

Section 1.11.2 deals with the aerodynamic data. The selection of a good aerodynamic model will depend upon a knowledge of the theory (see Section 17 of the Theoretical Manual). At the present time, only the Doublet Lattice method has been implemented. This method can be used for small sinusoidal motions of subsonic lifting surfaces of general configurations.

Section 1.11.3 deals with the interconnection between aerodynamic and structural degrees of freedom. The interpolation methods include both linear and surface splines. These methods are superior to high order polynomials since they tend to give smooth interpolation. They are based upon the theory of uniform beams and plates of infinite extent (see Section 17.2 of the Theoretical Manual).

Section 1.11.4 explains how to do modal flutter analysis by the k-method. Further details are given in the Rigid Format description (Section 3.20.).

Section 1.11.5 is a sample problem which shows how to analyze a simple structure for flutter using the Doublet Lattice theory and the k-method of flutter analysis.

1.11.2 Aerodynamic Modeling

The lifting surfaces must be idealized as planes parallel to the flow. The configuration is divided into plane panels, each of constant dihedral. These panels are further subdivided into "boxes" (see Figure 1), which are really trapezoids with parallel sides in the airflow direction. If an airfoil lies in (or nearly in) the wake of another, then the spanwise divisions should lie along the same streamline. The boxes should be arranged so that any fold or hinge lines lie along the box boundaries. The aspect ratio of the boxes should be roughly one or less. The size of the boxes will depend upon the basic wavelength. An approximate rule is that the number of boxes per reference chord is greater than eight times the reduced frequency.

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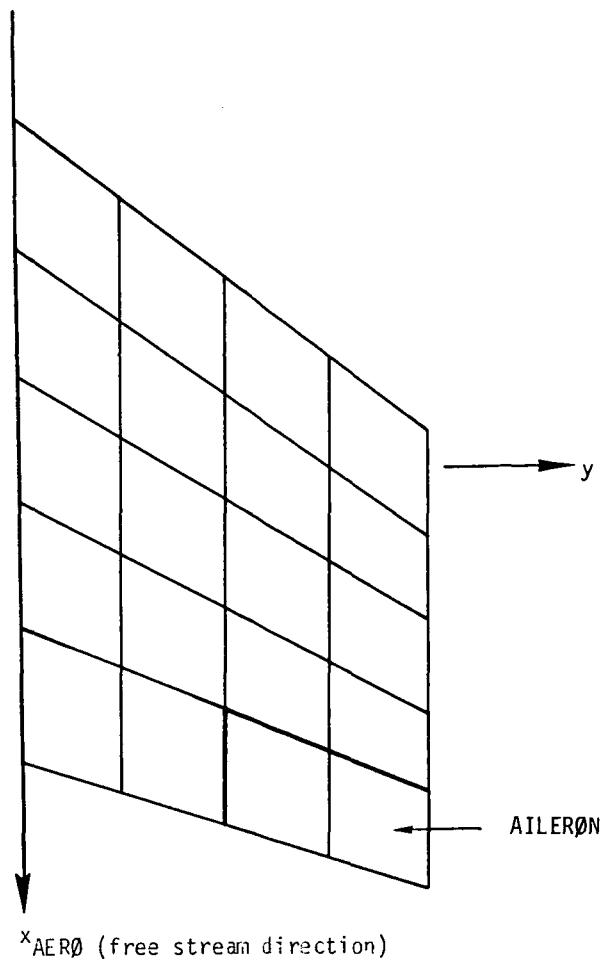


Figure 1. An aerodynamic panel subdivided into boxes.

Boxes should be concentrated near wing edges and hinge lines or any other place where downwash is discontinuous. A further discussion of the choice of models is found in Reference 1. Aerodynamic panels are assigned to groups. All panels within a group have aerodynamic interaction. The purpose of the groups is to reduce the time to compute aerodynamic matrices when it is known that aerodynamic coupling is unimportant, or to allow the analyst to investigate the effects of aerodynamic coupling.

The basic aerodynamic parameters are given on the AERØ bulk data card. A rectangular aerodynamic coordinate must be identified. The flow is in the $+x$ direction of this system. The use of symmetry (or antisymmetry) is recommended to analyze symmetric structures, simulate

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ground effects, or simulate wind tunnel walls. Any consistent set of units can be used for the dimensional quantities.

The panel is described by a bulk data CAERØ1 card. A property card PAERØ1 may be used to move the center of pressure, a procedure not generally recommended. The box divisions along the span can be determined either by specifying the number of equal boxes (NSPAN) or the identity (LSPAN) of an AEFACT data card which gives a list of division points in terms of percent span. A similar arrangement can be used in the chord direction. The locations of the two leading edge points may be specified in any coordinate system (CP) defined by the user (including BASIC). The lengths of the sides are specified by the user, and they are in the airstream direction, assuring that the panel is parallel to the flow. Every panel must be assigned to some group (IGID), which is usually 1 if all panels interact.

There will be many degrees of freedom associated with each aerodynamic panel. There is an aerodynamic grid point associated with each box within a given panel. These points are located at the center of each box, and are automatically numbered and sequenced by the program. The lowest aerodynamic grid point number for a given panel is assigned the same number the program user specifies for the panel designation. The grid point numbers increase in increments of 1 (see CAERØ data card figure) over all boxes in the panel. The user must be aware of these internally generated grids and ensure that their numbers are distinct from structural grids. These aerodynamic points will be used for output including displacements, plotting, matrix prints, etc. The local displacement coordinate system will have component T1 in the flow direction, and component T3 in the direction normal to the panel (the element coordinate system of CAERØ1).

1.11.3 The Interconnection Between Structure and Aerodynamic Models

The basis for interpolation to the aerodynamic degrees of freedom is based upon the theory of splines (Figure 2). High aspect ratio wings, or other beamlike structures, should use linear splines. Low aspect ratio wings, where the structural grid points are spread over an area, should use surface splines. Several splines can be used to interpolate the boxes on a panel; however, each box can refer to only one spline. Any box not referenced by a spline will be "fixed" and have no motion.

For both types of splines, the user must specify the structural degrees of freedom and the aerodynamic boxes involved. The structural points, called the g-set, can be specified by a list or by specifying a volume in space and determining all the grid points in the volume. The degrees

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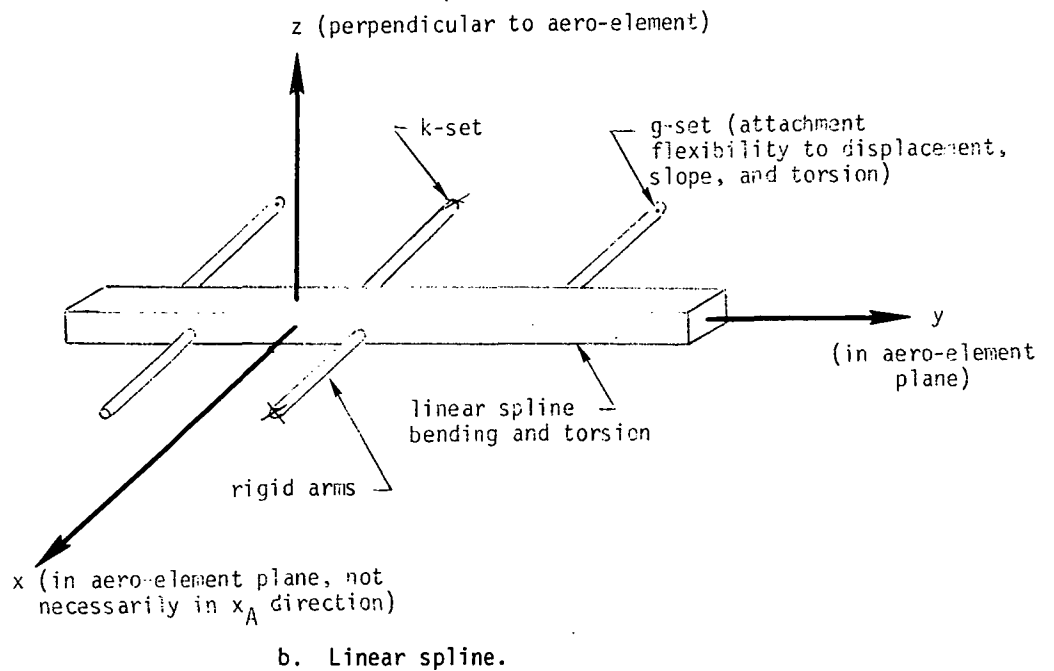
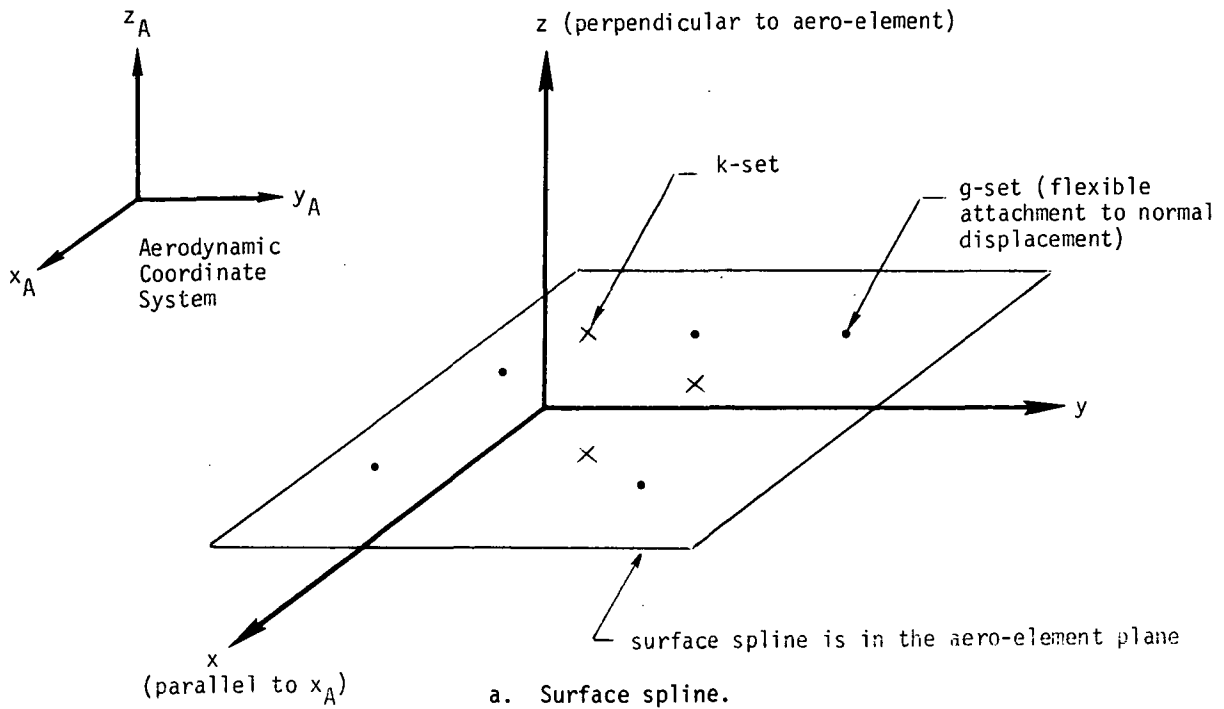


Figure 2. Splines and their coordinate systems.

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of freedom at the grid points include only the normal displacements for surface splines. For linear splines, the normal displacement is always used and, by user option, rotations in torsion or slopes may be included.

The SPLINE1 data card defines a surface spline. This can interpolate for any "rectangular" subarray of boxes on a panel. For example, one spline can be used for the inboard end of a panel and another for the outboard end. The interpolated grid points (set k) are specified by naming the lowest and highest elements in the area to be splined. The two methods for specifying the grid points use SET1 and SET2 data cards. A parameter DZ is used to allow some smoothing of the spline fit. If $DZ=0$ (the usual value), the spline will pass through all deflected grid points. If $DZ>0$, then the spline (a plate) is attached to the grid deflections via springs, which produce a smoother interpolation that does not necessarily pass exactly through all points.

The SPLINE2 data card defines a linear spline. As can be seen from Figure 2, this is really a generalization of a simple spline to allow for interpolation over an area. It is similar to the method often used by aeronautical engineers who assume that there is no curvature perpendicular to the elastic axis. The portion of a panel to be interpolated and the set of structural points are determined in the same manner as a SPLINE1. A NASTRAN coordinate system must be supplied to determine the axis of the spline. Since the spline has torsion as well as bending flexibility, the user may specify the ratio; the usual value is 1.0. The attachment flexibilities, D_z , $D_{\theta x}$, and $D_{\theta y}$ allow for smoothing, where usually all are taken to be zero. An exception would occur if the structural model does not have slopes defined, in which case the flexibility DTHX must be infinite.

1.11.4 Modal Flutter Analysis

A prerequisite to modal flutter analysis is the calculation of an aerodynamic matrix and the transformation to modal coordinates. This operation is often very costly and care should be taken to avoid unnecessary work. One method is to compute the modal aerodynamic matrix at a few Mach numbers and reduced frequencies and interpolate to others. Matrix interpolation is an automatic feature of Rigid Format 10. The MKAER01 and MKAER02 data cards allow the selection of parameters for matrix calculation. On restart, additional MKAER0i cards will cause the new matrix terms to be appended (if no other data cards are added to invalidate previously computed matrices).

The method of flutter analysis is specified on the FLUTTER bulk data card. The FLUTTER card is selected in case control by an FMETH00 card. At the present time, only the k-method of flutter

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analysis is available. This allows looping through three sets of parameters: density ratio (ρ/ρ_{ref} , ρ_{ref} is given on an AERØ data card); Mach number(m); and reduced frequency, k. For example, if the user specifies two values of each, there will be eight loops in the following order.

<u>LOOP</u>	<u>DENS</u>	<u>MACH</u>	<u>RFREQ</u>
1	1	1	1
2	2	1	1
3	1	1	2
4	2	1	2
5	1	2	1
6	2	2	1
7	1	2	2
8	2	2	2

Values for the parameters are listed on FLFACT bulk data cards. Usually, one or two of the parameters will have only a single value.

A parameter VREF may be used to scale the output velocity. This can be used to convert from consistent units (e.g., in/sec) to any units the user may desire (e.g., mph), determined from $V_{\text{out}} = V/V_{\text{REF}}$. Another use of this parameter is to compute flutter index, by choosing $V_{\text{REF}} = b\omega_{\theta} \sqrt{\mu}$.

If physical output (grid point deflections or element forces, plots, etc.) is desired rather than modal amplitudes, this data recovery can be made upon a user selected subset of the cases. The selection is based upon the velocity; the method is discussed in Section 3.20.3.

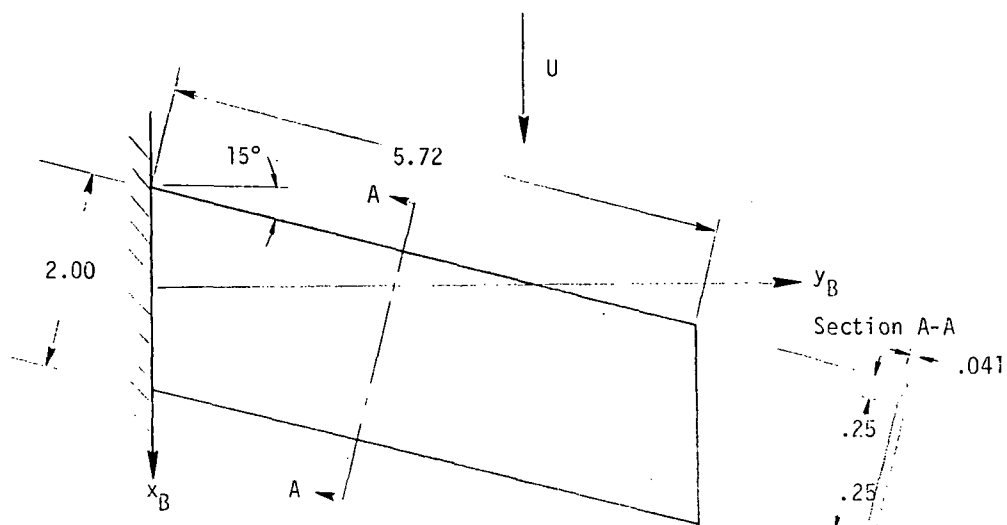
Subsets of flutter analysis for checking data are discussed in Section 3.20.5.

1.11.5 Sample Problem

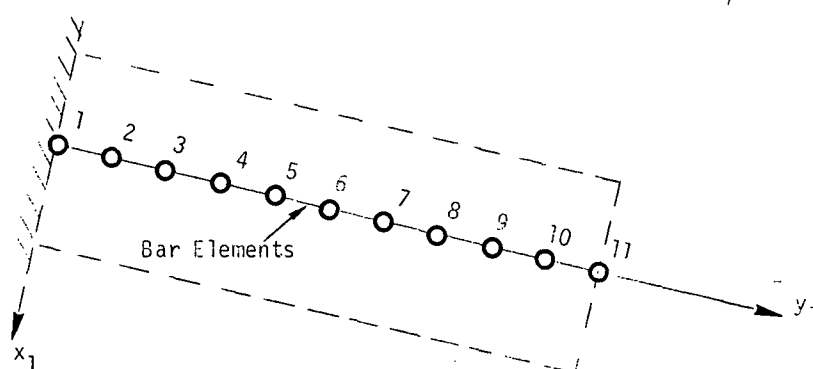
A sample problem (see Figure 3) has been chosen to illustrate flutter analysis. This model has been tested in a wind tunnel and analyzed using strip theory aerodynamics (see Reference 2). The analysis showed that "uncoupled" modes fortuitously provide a good result. This analysis has not included the bending-torsion elastic coupling at the root or the mass coupling at the tip. The NASTRAN deck (Figure 4) will be discussed to illustrate how to solve for flutter conditions using the k-method.

The structure will be modeled as a ten cell beam. A swept back coordinate system will be introduced to make it easier to model this beam. The global (i.e., local displacement) coordinate

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a. Planform.



b. Structural model.

101	105	109			
102	106	110	113	117	121
103	107	111	114	118	122
104	108	112	115	119	123
		116	120	124	

c. Aerodynamic model.

Figure 3. Fifteen degree sweep model.

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```

ID    DEMO,AERO
APP   AERO
SOL   10,0
TIME  10
ALTER 87 $
MATGPR GPL,uset,sil,phia//c,n,fe/c,n,a $
ENDALTER $
CEND
TITLE = AEROELASTIC MODAL FLUTTER ANALYSIS DEMONSTRATION PROBLEM
SUBTITLE = SEE NASTRAN DEMONSTRATION PROBLEMS MANUAL FOR RESULTS
LABEL=K VALUES .200(*) .167(0) .143(1) .125(2) .111(3) .100(4)
SPC=1
METHOD=10
CMETHOD=20
FMETHOD=30
OUTPUT(XYOUT)
CURVELINESYMBOL=-1
XYPAPERPLOT VG / 1(G,F) 2(G,F) 3(G,F) 4(G,F) 5(G,F) 6(G,F)
BEGIN BULK
$
$ 1 . 2 . 3 . 4 . 5 . 6 . 7 . 8 . 9 . 10
$
$ GEOMETRY AND CONSTRAINTS
CORD2R 1 0. 0. 0. 0. 0. 1. +C1
+C1 .96593 -.25882 0.
GRDSET 1 1 126
GRID 1 0. .0 0.
GRID 2 0. .572 0.
GRID 3 0. 1.144 0.
GRID 4 0. 1.716 0.
GRID 5 0. 2.288 0.
GRID 6 0. 2.86 0.
GRID 7 0. 3.432 0.
GRID 8 0. 4.004 0.
GRID 9 0. 4.576 0.
GRID 10 0. 5.148 0.
GRID 11 0. 5.72 0.
SPC1 1 345 1
$
$ STRUCTURAL ELEMENTS
CBAR 1 1 1 2 0. 0. 1. 1
CBAR 2 1 2 3 0. 0. 1. 1
CBAR 3 1 3 4 0. 0. 1. 1
CBAR 4 1 4 5 0. 0. 1. 1
CBAR 5 1 5 6 0. 0. 1. 1
CBAR 6 1 6 7 0. 0. 1. 1
CBAR 7 1 7 8 0. 0. 1. 1
CBAR 8 1 8 9 0. 0. 1. 1
CBAR 9 1 9 10 0. 0. 1. 1
CBAR 10 1 10 11 0. 0. 1. 1
PBAR 1 1 7.175-2 9.83-6 36.8-6
MAT1 1 10.4+6 3.9+6 2.61-4
PARAM COUPMASS1
CMASS2 12 2.8-6 2 5
CMASS2 13 2.8-6 3 5
CMASS2 14 2.8-6 4 5
CMASS2 15 2.8-6 5 5
CMASS2 16 2.8-6 6 5
CMASS2 17 2.8-6 7 5
CMASS2 18 2.8-6 8 5
CMASS2 19 2.8-6 9 5
CMASS2 20 2.8-6 10 5
CMASS2 21 1.4-6 11 5
$

```

Figure 4. NASTRAN deck for fifteen degree sweep model.

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```

$ AERODYNAMIC ELEMENTS
CAERO1 101 1 1 6 4 1 +CA101
+CA101 -1. -.26795 0. 2.0706 -1. 5.45205 0. 2.0706
PAERO1 1
SPLINE2 100 101 101 124 100 0. 1. 1 +SP
+SP 0. 0.
SET1 100 1 THRU 11
$
$ CONTROL DATA
EIGR 10 GIV .3 .1 6 +ER
+ER MAX
PARAM LMODES 3
AERO 0 1.3+4 2.0706 1.145-7
MKAERO1 .45 +MK
+MK 0. .1 .2
FLUTTER 30 K 1 2 3 L 3
FLFACT 1 .967
FLFACT 2 .45
FLFACT 3 .2 .16667 .14286 .125 .11111 .1
EIGC 20 HESS MAX +EC
+EC .3
ENDDATA

```

Figure 4. NASTRAN deck for fifteen degree sweep model (continued).

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system for the grid points will be in the swept back system. Twenty-four aerodynamic boxes will be used. The deflections of the aerodynamic boxes will be interpolated using a linear spline.

The Executive Control Deck (from ID to CEND) selects the modal flutter analysis, e.g., APP and SØL cards. A time estimate (CPU min.) is required. The three card ALTER package (not required) will print the nonzero components of the mode shapes of the structure; the mode frequencies are an automatic output of this Rigid Format. If desired, the problem can be checkpointed using modal analysis (Rigid Format 3), and then restarted in flutter analysis (Rigid Format 10), allowing better output format of mode shapes.

The Case Control Deck is used to select constraints, methods, and output. In this problem, SPC set 1 is used to cantilever the root of the beam, and no MPC's are used. A METHØD card must be used to select an EIGR data card for real eigenvalue extraction. An FMETHØD card must select a FLUTTER data card for flutter analysis. A CMETHØD card must select an EIGC control for complex eigenvalue analysis. If desired solution set (SDISP gives modal quantities) or physical set (DISP, STRESS, etc.) output may be requested, but this is not usually done. An automatic flutter summary is printed unless parameter PRINT is set to NØ. The XYØUT request shown will plot V-g and V-f split frame "plots" on the printer output. To produce plots, it is necessary to specify a plotter, request a plot tape, and specify XYPLØT VG. The "curves" (e.g., 1 through 6 in the example) refer to the loops of flutter analysis.

The geometry and constraint bulk data is discussed in previous sections of this manual, and there are no special rules for aeroelastic problems. The structural elements are BAR elements with MASS2 used for torsional inertia. The CØUPMASS option is used to provide a nonsingular mass matrix so that the Given's method of eigenvalue extraction can be used. The bending moment of inertia and torsional rigidity (on the PBAR data card) have been adjusted to match experimental mode frequencies.

The aerodynamic boxes are defined by the CAERØ1 data card. The element number (e.g., 101) becomes the ID of the lowest numbered box. Other boxes are numbered as shown in Figure 3. A property card must be referenced. The leading edge corners of the panel will be specified in coordinate system 1 for this example; however, any defined system may be used. Since equal box sizes are desired, the NSPAN and NCHØRD options are used to specify the numbers. If unequal divisions were desired, LSPAN and LCHØRD would be used to specify lists referenced on AEFACT data cards.

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The interpolation is specified by a SPLINE2 (linear spline) data card. This must have an element number. For aerodynamic boxes, the lowest and highest numbered boxes in a rectangular array must be specified. In this case, all are desired from 101 through 124. In order to provide data for the spline, the user must determine which box numbers will be assigned to the boxes. All grid points are used in this example, as specified in SET 100.

An EIGR data card will usually use either the INV or GIV method of eigenvalue extraction. In the example, six mode shapes are found, and a parameter LMØDES is used to limit the modal formulation to three. Usually, these numbers agree unless one is interested in checkpointing more modes for possible use in restart, examining shapes of neglected modes, or some other special reason. The AERØ data card specifies aerodynamic coordinate system (for this example, BASIC), velocity of sound (not used), reference length, and density. The MKAERØ1 data card will cause the aerodynamic matrix to be computed for Mach number 0.45 and reduced frequencies of 0.0, 0.1, and 0.2.

The FLUTTER data card requests the k-method (the only one now implemented) and selects FLFACT cards specifying density ratios, Mach numbers, and reduced frequencies. The analysis will loop through all combinations, with density on the inner loop and Mach number on the outermost loop. This arrangement also allows, for example, plots of V-g versus density. In the example given, probably typical, only one density and Mach number were specified. Both linear and surface splines are available for interpolation of aerodynamic matrices to intermediate values of M (Mach number) and k (reduced frequency). The linear, L, method is used when the matrix has been computed at the desired Mach numbers. The EIGC data card is required, and the HESS method is recommended. The number of vectors must be specified and will usually agree with the number of modes saved for output specified on the FLUTTER data card.

Results are presented in the Demonstration Problems Manual.

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REFERENCES

1. Giesing, J. P., T. P. Kalman and W. P. Rodden, "Subsonic Unsteady Aerodynamics for General Configurations," Part II; Volume I, Application of the Doublet-Lattice Method and the Method of Images to Lifting-Surface/Body Interference; AFFDL-TR-71-5; April 1972.
2. Yates, E. C. and R. M. Bennett, "Use of Aerodynamic Parameters From Nonlinear Theory in Modified-Strip-Analysis Flutter Calculations for Finite-Span Wings at Supersonic Speeds; NASA TN D-1824, July 1963.

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1.12 CYCLIC SYMMETRY

Many structures, including pressure vessels, rotating machines and antennae for space communications, are made up of virtually identical segments that are symmetrically arranged with respect to an axis. There are two types of cyclic symmetry as shown in Figures 1 and 2: simple rotational symmetry, in which the segments do not have planes of reflective symmetry and the boundaries between segments may be general doubly-curved surfaces; and dihedral symmetry, in which each segment has a plane of reflective symmetry and the boundaries between segments are planar. The use of cyclic symmetry allows the user to model only one of the identical sub-structures. There will also be a large saving of computer time for most problems. The theoretical treatment for cyclic symmetry is given in Section 4.5 of the Theoretical Manual.

The total model consists of N identical segments which are numbered consecutively from 1 to N. The user supplies a NASTRAN model for one segment, using regular elements and standard modeling techniques, except grid points are not permitted on the polar axis. All other segments and their coordinate systems are automatically rotated to equally spaced positions about the polar axis by the program. The boundaries must be conformable, i.e., the segments must coincide. This is easiest to insure if a cylindrical or spherical coordinate system is used, but such is not required. The PARAM card, CTYPE, is used to specify either rotational symmetry or dihedral symmetry and the number of segments, N, in the structural model is specified on the PARAM card, NSEGS. As indicated in Figure 2, dihedral symmetry provides solutions for each segment and its reflected image. This requires application of both symmetric and antisymmetric boundary conditions.

In rotational symmetry the basic transformation equation between the structure segments $n = 1, 2, \text{etc.}$ and the harmonic indices $k = 0, 1, 2, \text{etc.}$ is

$$u^n = \bar{u}^0 + \sum_{k=1}^{KMAX} [\bar{u}^{kc} \cos(n-1)ka + \bar{u}^{ks} \sin(n-1)ka] \quad (1)$$

where

u^n is any displacement, load, stress, etc., on the n^{th} segment ($n = 1, 2 \dots \text{NSEGS}$),
 \bar{u}^0 , \bar{u}^{kc} , \bar{u}^{ks} are the corresponding cyclic coefficients used in the solution which define the entire structure,

k is the cyclic index (i.e., KINDEX),

$KMAX$ is the limit ($KMAX \leq \frac{N}{2}$) of k . (If all values of k are used, the transformation is exact),

and

$a = \frac{2\pi}{\text{NSEGS}}$ is the circumferential angle for each segment.

In dihedral symmetry the repeated request may be divided into two half segments divided by a plane of symmetry. The solution is obtained for symmetric motions (S) and antisymmetric motions (A) of the right half segment modeled by the user. Thus, for each cyclic index, K, four coefficients are obtained defining the variable, n, i.e., $\bar{u}^{ks,S}$, $\bar{u}^{kc,S}$, $\bar{u}^{ks,A}$ and $\bar{u}^{kc,A}$. In the right hand segment the terms are added

$$\text{Right side:} \quad \bar{u}^{ks} = \bar{u}^{ks,S} + \bar{u}^{ks,A} \quad (2)$$

In the left hand mirror image the antisymmetric solution is subtracted.

$$\text{Left Side:} \quad \bar{u}^{ks} = \bar{u}^{ks,S} - \bar{u}^{ks,A} \quad (3)$$

The reason for using dihedral symmetry is to reduce the size of the model by one half. However in static analysis, this procedure requires twice as many solutions as in rotational cyclic symmetry. In normal modes analysis only the modes for the symmetrical components $\bar{u}^{kc,S}$ and $\bar{u}^{ks,A}$ are obtained. The modes for the other two terms are identical and correspond to a one segment rotation of the structure.

The two boundaries are called sides 1 and 2. In the case of rotational symmetry, side 2 of segment n is connected to side 1 of segment n+1, as shown in Figure 1. In the case of dihedral symmetry, side 1 is on the boundary of the segment and side 2 is on the plane of symmetry for the segment, as shown in Figure 2. In either case the grid point numbers on sides 1 and 2 must be specified on the bulk data card, CYJØIN.

As indicated in the Theoretical Manual Section 4.5, the cyclic symmetry analysis uses a finite Fourier transformation. Hence, the use of cyclic symmetry procedures does not introduce any additional approximations beyond those normally associated with finite element analysis. In the case of static analysis, a shortened approximate method may be used where the maximum value of the harmonic index is specified on the PARAM card, KMAX. The default procedure is to include all harmonic indices. The use of a smaller number of harmonic indices is similar to truncating a Fourier series. The stiffness associated with the higher harmonic indices tends to be large, so that these components of displacements tend to be small. In the case of vibration analysis, the solutions are performed separately for each harmonic index. The harmonic index for each solution is specified on the PARAM card, KINDEX. The standard restart procedures can be used to calculate vibration modes for additional harmonic indices.

No restrictions are placed on the use of the single point constraint, the multipoint constraint, or the ØMIT feature of NASTRAN, other than that the constraints must be the same for each segment. Constraints between segments are automatically applied to the degrees of freedom

at grid points specified on CYJØIN bulk data cards which are not otherwise constrained. The SPCD bulk data card may be used to vary the magnitude of enforced displacements for each of the segments. In the case of static analysis, the ØMIT feature may be used to remove all degrees of freedom at internal grid points without any loss of accuracy. Since this reduction is applied to a single segment prior to the symmetry transformations, it can greatly reduce the amount of subsequent calculation. In the case of vibration analysis, the ØMIT feature is used in the usual way to reduce the size of the analysis set and involves the usual approximations. The SUPØRT card for free bodies cannot be used with cyclic symmetry.

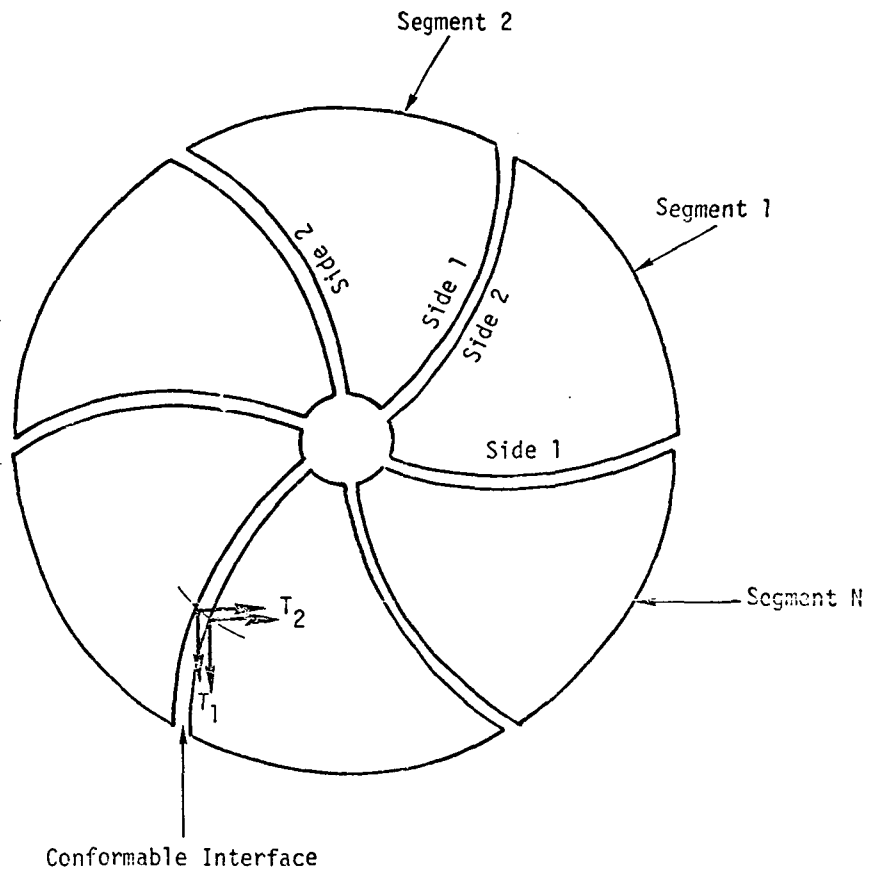
Static loads are applied to the structural model in the usual way. A separate subcase is defined for each segment (half segment for dihedral symmetry) and loading condition. The subcases for static loading must be ordered sequentially, according to the segment numbers. Multiple loading conditions for each segment must be in consecutive subcases. In the case of rotational symmetry, there will be a number of subcases equal to the number of segments in the structural model for each loading condition. In the case of dihedral symmetry, there will be twice as many subcases as for rotational symmetry because of the two symmetric components. If there is more than a single loading condition, the number of loading conditions must be specified on the PARAM card, NLØAD.

An alternate procedure for specifying the static loads may be used if the transform values of the forcing functions are known. In this case, the transform values of the loads are specified directly on the usual loading cards. The PARAM card, CYCIØ, must be included in the Bulk Data Deck to indicate that cyclic transform representation rather than physical segment representation is being used for the static loads. If this option is used, the subcases must be ordered according to the symmetrical components with the cosine cases preceding the sine cases for each symmetrical component. The output quantities will also be prepared in terms of the symmetric components.

If the loading is specified in terms of the physical segments, the data reduction will also be done in terms of the physical variables. All of the normal output, including structure plots, are available. No provision is made to recover physical segment data in vibration analysis. The available output data does, however, include the symmetrical components of dependent displacements, internal forces and stresses.

For purposes of minimizing matrix bandwidth, the equations of the solution set are normally sequenced with the cosine terms alternating with the sine terms. The user may request an alternate sequence on the PARAM card, CYCSEQ, which orders all cosine terms before all sine terms. The latter may improve efficiency when all of the interior points have been omitted.

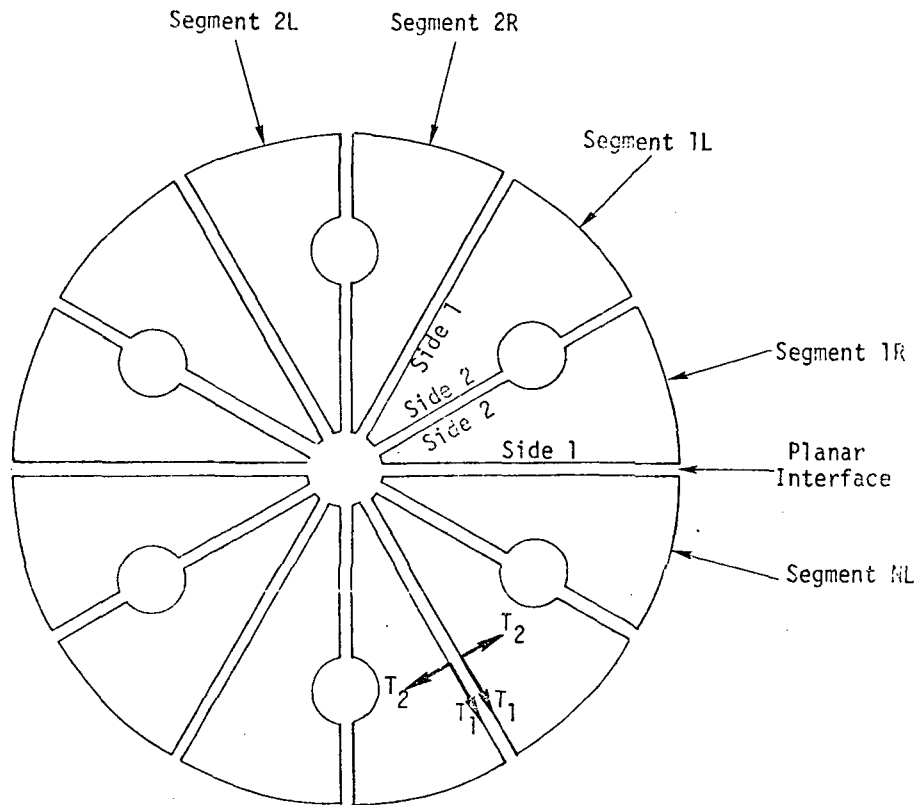
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1. The user models one segment.
2. Each segment has its own coordinate system which rotates with the segment.
3. Segment boundaries may be curved surfaces. The local displacement coordinate systems must conform at the joining points. The user gives a paired list of points on Side 1 and Side 2 which are to be joined.

Figure 1. Rotational symmetry

CYCLIC SYMMETRY



1. The user models one-half segment (an R segment). The L half segments are mirror images of the R half segments.
2. Each half segment has its own coordinate system which rotates with the segment. The L half segments use left hand coordinate systems.
3. Segment boundaries must be planar. Local displacement systems axes, associated with inter-segment boundaries, must be in the plane or normal to the plane. The user lists the points on Side 1 and Side 2 which are to be joined.

Figure 2. Dihedral symmetry

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1.13 FULLY STRESSED DESIGN

The fully stressed design option is part of the static analysis rigid format for structural analysis. Functional modules (ØPTPR1 and ØPTPR2) are provided to automatically adjust the properties based on maximum stress levels, and to control the number of design iterations based on user-supplied convergence criteria. All elements using a common property are sized together, i.e., a plate with uniform thickness remains uniform. If the user wishes to scale the properties for each element separately, each element must have its own property card. After a sufficient number of iterations, the element properties will be adjusted to the minimum values necessary to carry the prescribed loads.

The process begins by performing a static analysis for all loading conditions using the initial values for all element properties. A new property, P_2 , will be scaled such that

$$P_2 = P_1 \left[\frac{\alpha}{\alpha + (1-\alpha)\gamma} \right] \quad , \quad (1)$$

where P_1 is the current property value and γ is an iteration factor with a default value of unity.

The scale factor, α , is defined as follows:

$$\alpha = \text{Max} \left(\frac{\sigma}{\sigma_\ell} \right) \quad , \quad (2)$$

where σ is a stress value and σ_ℓ is a stress limit. The maximum value of α is taken for all loading conditions. Values of γ smaller than unity limit the property change in a single iteration, and thereby tend to improve the stability of the process. The maximum change in any property is limited by

$$K_{\min} < \frac{P_2}{P_i} < K_{\max} \quad , \quad (3)$$

where P_i is the initial value of the property and K_{\min} and K_{\max} are user-supplied limits.

Convergence is achieved by completing the user-specified number of iterations, by having all selected element properties reach the user-specified limits, or by satisfying the following convergence criteria:

$$\frac{|\sigma - \sigma_\ell|}{\sigma_\ell} < \epsilon \quad , \quad (4)$$

where ϵ is a user-supplied convergence limit.

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The following actions are required by the user in order to utilize the fully stressed design capability:

1. The user must select stress output in the Case Control Deck for all elements that will participate in the fully stressed design.
2. All required stress limits must be specified on the structural material cards associated with element properties that will participate in the fully stressed design.
3. The property optimization parameters must be specified on the bulk data card PØPT. This card contains user-specified values for the maximum number of iterations, the convergence criteria (ϵ), the iteration factor (γ), and output options to print and/or punch the calculated values of the element properties.
4. The property optimization limits (K_{\min} and K_{\max}) must be specified on the PLIMIT bulk data card if the user wishes to limit the maximum and minimum values of the element properties.

The detailed definitions of the scale factors for each of the element types are given in Table 1. The symbols σ_t , σ_c and σ_s represent the limiting stress values in tension, compression and shear, given on the structural material cards. All of the properties listed for each element are scaled in the same way, i.e., both the area and torsional constant for the RØD are modified using the same scale factor.

FULLY STRESSED DESIGN

Table 1. Scale Factors for Fully Stressed Design

Element	Stress Value Used	Scale Factor (α)	Properties Changed
RØD TUBE	Axial Tension (σ_1) Axial Compression (σ_2) Torsion (τ)	$\text{Max} \left(\frac{\sigma_1}{\sigma_t}, \frac{\sigma_2}{\sigma_c}, \frac{\tau}{\sigma_s} \right)$	Area (A) Torsional Constant (J)
BAR	Fiber Stress { End a (σ_{a1}) Tension { End b (σ_{b1}) Fiber Stress { End a (σ_{a2}) Compression { End b (σ_{b2})	$\text{Max} \left(\frac{\sigma_{a1}}{\sigma_t}, \frac{\sigma_{b1}}{\sigma_t}, \frac{\sigma_{a2}}{\sigma_c}, \frac{\sigma_{b2}}{\sigma_c} \right)$	Area (A) Torsional Constant (J) Moments of Inertia (I_1, I_2, I_{12})
TRMEM QDMEM	Principal Tension (σ_1) Principal Compression (σ_2) Maximum Shear (τ_m)	$\text{Max} \left(\frac{\sigma_1}{\sigma_t}, \frac{\sigma_2}{\sigma_c}, \frac{\tau_m}{\sigma_s} \right)$	Thickness (t)
TRPLT QDPLT TRBSC	Same as Above (Fiber Distances z_1 & z_2)	Same as Above	Moment of Inertia (I)
TRIA1 QUAD1	Same as Above	Same as Above	Moment of Inertia (I) Membrane Thickness (t_1)
TRIA2 QUAD2	Same as Above	Same as Above	Thickness (t)
SHEAR	Maximum Shear (τ_m)	$\frac{\tau_m}{\sigma_s}$	Thickness (t)

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1.14 AUTOMATED MULTI-STAGE SUBSTRUCTURING

Large and complex structural analysis problems can be solved for static and/or normal modes response using the automated multi-stage substructuring features of NASTRAN. The user subdivides the intended model into a set of smaller more elementary partitions called basic substructures. These components of the whole structure can be modeled independently, checked for accuracy and then assembled automatically to form a composite model representing the whole structure for final solution. This approach offers the following advantages:

1. Each component model of the overall structure (e.g., wing, fuselage, engine nacelles, landing gear, etc.) may be developed independently.
2. Larger component substructures may themselves be assembled from yet smaller component substructures for multi-stage substructure analyses.
3. Each component substructure may be validated independently, plotted and analyzed prior to assembly and solution of the integrated whole model.
4. Changes due to errors, model modifications, and/or design alterations may be effected for any basic substructure and reintegrated into the overall structure at a minimum cost.
5. Via matrix reduction of the stiffness and mass matrices of neighboring substructures (see Theoretical Manual, Section 4.6), their interaction effects on any given component can be economically included in the separate analysis of that particular component.

In effect, the concept of multi-stage substructuring is analogous to the elementary finite element theory whereby simple beam, plate, and solid elements are replaced by more complex elements each of which, in turn, may represent an assemblage of simple or complex elements.

In order to effectively employ this automated substructuring capability of NASTRAN for static and normal modes analyses, the user should gain an overall understanding of the basic program design concepts, the data base on which it operates, and the control functions provided. These are outlined in the next section which is then followed by a more detailed description of how to use the features of the program including examples of the input data flow. A detail description of each substructuring control card and a summary of the associated bulk data cards is provided in Section 2.7. The detailed definition of each of these bulk data cards is included with the alphabetical listing of all the other bulk data cards in Section 2.3.

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1.14.1 Substructuring Terminology

This section summarizes the basic concepts of operation provided in NASTRAN for executing an automated multi-stage substructure analysis. Definitions are given in Table 1 for the specialized terminology used in describing the operation and control of each execution step.

A static or normal modes analysis using substructuring techniques can be divided into three basic phases of operation:

Phase 1: Initial generation of individual basic substructure matrices.

Phase 2: Substructure matrix reduction and assembly, solution of the assembled substructure, and recovery of substructure displacements and reaction forces.

Phase 3: Completion of the analysis with conventional selective output for each individual basic substructure.

Each of these three phases of operation can be performed using Rigid Formats 1, 2, or 3 of NASTRAN according to the results desired. Control of the individual execution steps is provided via the Substructure Control Deck. Section 2.7 presents detailed descriptions of each command and summarizes the special Bulk Data cards provided for substructuring. The Substructure Control Deck is input as shown in Figure 1 between the standard Executive Control and Case Control Decks now used by NASTRAN. Each substructure control command is automatically translated into appropriate DMAP ALTER cards to augment the specified Rigid Format sequence. The user may also include his own DMAP ALTER commands or he may modify a previously defined DMAP sequence as described in Section 2.7.2.

1.14.1.1 Storage of Substructure Data

The data required for each basic substructure and for subsequent combinations of substructures is stored on a Substructure Operating File (SØF). The SØF data are stored in direct access format on disk or drum during a NASTRAN execution. These data may also be stored on tape between runs for backup storage or for subsequent input to other computers. A schematic diagram of data flow is given in Figure 2.

The SØF file which contains the data items listed in Table 2 is used to communicate between each phase of operation and between each step of the Phase 2 operation. Thus, the user is allowed to develop his analysis in separate steps as he builds his final solution structure without use of the checkpoint/restart feature of NASTRAN. He may execute a series of Phase 1 runs to build

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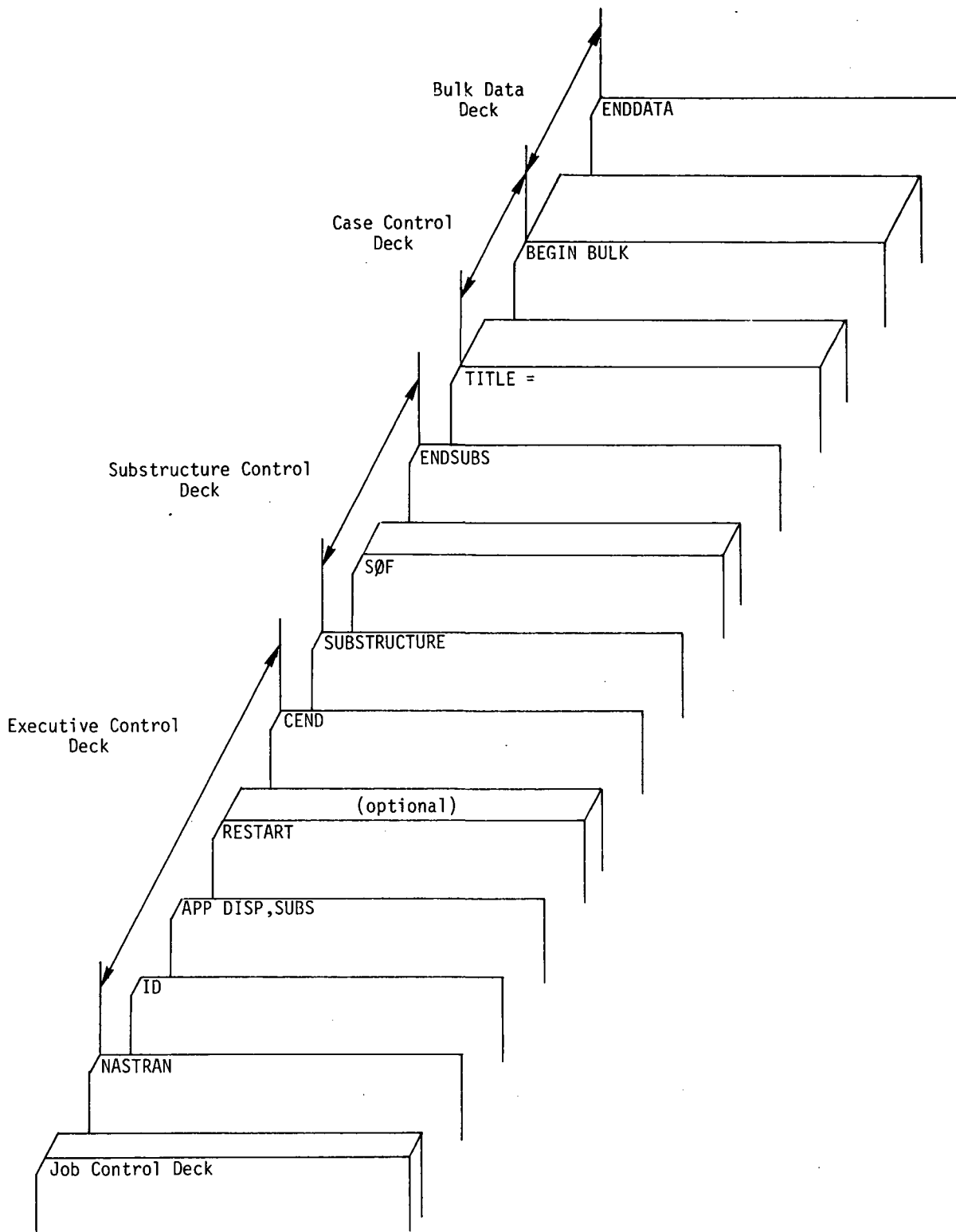
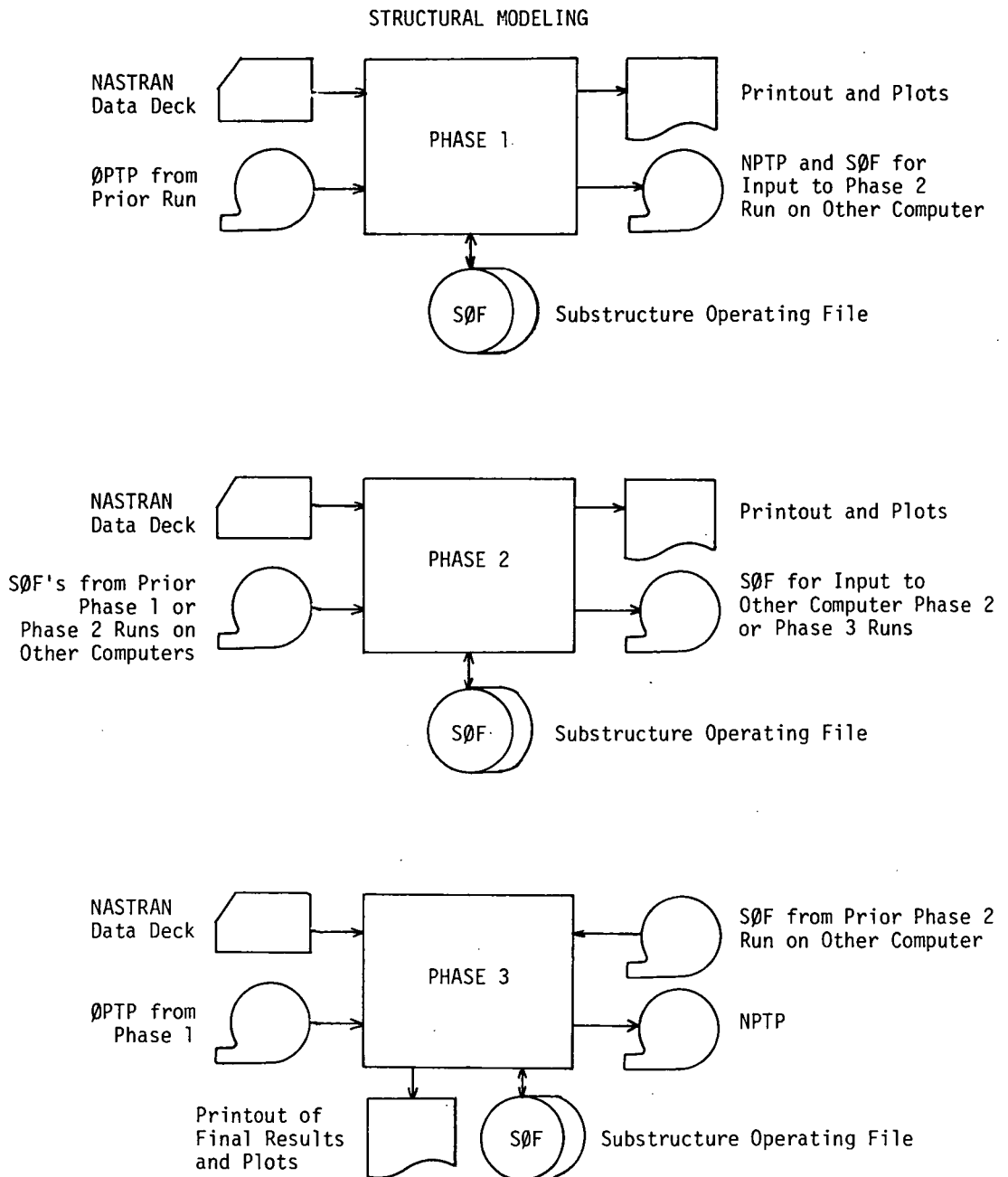


Figure 1. Substructuring input data deck.



Note: If all processing is performed on the same computer, SØF tape output is not required. All communication may be carried out using the same SØF disk/drum throughout.

Figure 2. Data file organization for NASTRAN multi-stage substructuring.

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Table 1. Definitions of Substructure Terminology.

Basic Substructure	- A structure formulated from finite elements in Phase 1.
Boundary Set	- Set of degrees of freedom to be retained in a Phase 2 reduce operation.
Combine Operation	- Merge two or more structures by connecting related degrees of freedom. The matrix elements for connected degrees of freedom are added to produce the combined structure matrices, and the substructure load vectors are processed and stored for subsequent combination at solution time.
Component Substructure	- Any basic or pseudostructure comprising a part of an assembled substructure.
Connection Set	- Set of grid points and their component degrees of freedom to be connected in adjoining structures.
Equivalence Operation	- The creation of an image substructure equivalent to a primary substructure.
Phase (1, 2, or 3)	- Basic steps required for multi-stage substructure processing with NASTRAN - creation, combination, reduction, solution and recovery, and detail data recovery.
Primary Substructure	- Any basic substructure or any substructure resulting from a combine or reduce operation.
Pseudostructure	- A combination of component substructures.
Reduce Operation	- Structural matrix and load vector reduction process to obtain smaller matrices.
Secondary Substructure	- An image substructure created from an equivalence operation.
SØF	- Substructure Operating File. Contains all data necessary to define a structure at any stage, including solutions.
Solution Structure	- The resulting substructure to be used in the solve operation.
Solve Operation	- To obtain solutions using the present structural matrices and user-defined input data.

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Table 2. Substructure Item Descriptions.

<u>Item Name</u>	<u>Description</u>
EQSS	External grid point and internal point equivalence data
BGSS	Basic grid point coordinates
CSTM	Local coordinate system transformation matrices
LØDS	Load set identification numbers
LØAP	Load set identification numbers for appended load vectors
PLTS	Plot sets and other data required for Phase 2 plotting
KMTX	Stiffness matrix
LMTX	Decomposition product of REDUCE operation
MMTX	Mass matrix
PAPP	Appended load vectors
PVEC	Load vectors
PØAP	Appended load vectors on omitted points
PØVE	Load vectors on points omitted during matrix reduction
UPRT	Partitioning vector used in matrix reduction
HØRG	H or G transformation matrix
UVEC	Displacement vectors or eigenvectors
QVEC	Reaction force vectors
SØLN	Load vectors or eigenvalues used in a solution

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all basic substructures prior to any reduction or combination in Phase 2, or he may build component pseudostructures from a few basic substructures and return later to add other basic substructures to his SØF file as required.

Once the final solution model is established, the user may solve his problem and recover results for any level of component pseudo- or basic substructure. Detail element stresses and element forces or support reactions specified with the basic substructure can be recovered in Phase 3. These results in Phase 3 may be recovered using the original data deck or by restarting from a checkpointed Phase 1 execution.

The physical characteristics of the SØF and the procedures for managing the data on the SØF are described in Section 1.14.2.

1.14.1.2 Identification of Substructure Data

The user controls each step in the analysis by specifying the substructure commands to be executed and the names, such as HUB, WING, RØØT, etc., of each substructure to be used in that step. Automatically the program retrieves all the relevant data for the named substructures from the SØF, performs the matrix operations requested, and stores the results on the SØF. Thus, the user is freed from the tedious task of bookkeeping. Additional commands have also been provided to facilitate the examination of any data item stored on the SØF and to eliminate any data no longer needed or incorrectly specified due to input data errors.

All specific references to grid points for connection or boundary sets, releases, and loads, etc. are made with respect to the basic substructure name. The names of any component substructure can be used for the combine, reduce, equivalence, solve, and recover operations. However, no component substructure name may be used more than once while building the solution structure. If the same component substructure is to be used more than once, e.g., identical components are to be used to create the full model, the equivalence operation should be used to assign unique names for all substructures comprising that component. The data for the equivalent or secondary image substructures will be automatically stored on the SØF for future reference. New names will be created for each lower level component of the equivalenced substructure simply by adding a user specified prefix to the old names. The user can then reference the prefixed name to obtain results for the secondary structure during the recovery operations in Phase 2 or in Phase 3.

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1.14.1.3 Input Data Checking

Several features have been provided for input data checking. Principal among these is the DRY run option. This option allows the user to submit his run to have the program validate the consistency of his command structure and his data without actually performing the more time consuming matrix operations. Assuming his input is found to be consistent, the run may be resubmitted with the GO option to complete the matrix processing.

Also available is a STEP option which first checks the data and then executes the matrix operations one step at a time. If errors are detected in the data, the matrix operations are skipped and the remainder of the processing sequence is executed as a DRY run only.

A second feature is also provided which allows the user to process only selected matrix data. For example, if the user finds that after having assembled his solution structure he wishes to add new loading conditions, or he wishes to obtain normal modes but did not have the mass matrix, he may re-execute the sequence of matrix operations to process only the load or mass matrix. First, however, the user must remove (EDIT or DELETE) the old loading data from the SØF to free that space for the new matrix data to be stored.

A third feature is available for displaying all the relevant substructuring data generated by the program. A description of the SØF data items for each substructure is given in Section 1.14.2, Table 2. Both the combine and reduce operations involve specification of grid point and degree of freedom data related to the basic substructures involved. The automatic generated or manually specified connectivities are critical to the combine operation. Using the output options provided, the user can verify explicitly each and every connectivity. The reduce operation requires the user specify the degrees of freedom to be retained. These are also identified by basic substructure grid point numbers. If desired, the user may also obtain lists of all the retained degrees of freedom of the resulting pseudostructure to verify the completeness and accuracy of his input.

Examples of the output generated are given in Figure 3. Two items in these examples require explanation to assist in their interpretation. The columns labeled "DEGREES OF FREEDOM" and "COMPONENT DØF" show entries containing six digit integers of "1" through "6". These represent the components of displacement and rotation at the grid point in question. These are read from right to left in the usual convention of NASTRAN such that the integer "23" represents displacement components 2 and 3 or y and z displacements, respectively.

SUMMARY OF PSEUDOSTRUCTURE CONNECTIVITIES			
INTERNAL POINT NO	DEGREES OF FREEDOM	WING001	WING002
1	123	WING001 13	WING002 13
2	123	WING001 27	WING002 27
3	23	WING001 14	WING002 14
4	23	WING001 28	WING002 28

EQSS ITEM FOR PSEUDOSTRUCTURE WING			
INTERNAL POINT ID	GRID POINT ID	INTERNAL POINT ID	COMPONENT DOF
1	13	1	123
2	14	3	23
3	27	2	123
4	28	4	23

BGSS ITEM FOR PSEUDOSTRUCTURE WING				
INTERNAL POINT ID	CSTM ID NO.	COORDINATES		
		X1	X2	X3
1	0	-0.433013E+01	0.375000E+02	0.500000E+01
2	0	-0.433013E+01	0.375000E+02	-0.500000E+01
3	0	0.600000E+02	0.375000E+02	0.500000E+01
4	0	0.600000E+02	0.375000E+02	-0.500000E+01

Figure 3. Sample of output options for reduce and combine operations.

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The column heading "INTERNAL POINT NO" references the internally generated "grid points" of the resulting pseudostructure. In the example showing pseudostructure connectivities, the internal point number 4 represents the connectivity of components 2 and 3 at grid point 28 in basic substructure WING001 to components 2 and 3 at grid point 28 in basic substructure WING002.

The printout of the EQSS item in Figure 3 for pseudostructure WING (which comprises the two basic substructures WING001 and WING002) shows again which degrees of freedom are retained in the substructure from the basic substructure WING001. Note that these degrees of freedom correlate exactly to the connectivities already discussed. That correlation can be found by looking up the internal point number.

The BGSS item displays all the internal point numbers for the pseudostructure WING along with its coordinates in that pseudostructure basic system. The "CSTM ID NO." column indicates the existence (if any) of local coordinate systems associated with those internal points. If the entry is "0", the displacement components will be in that pseudostructure basic system. Otherwise, they will be in a local system which may be checked by requesting the optional printout of the "CSTM" item from the SØF for that pseudostructure.

1.14.2 The Substructure Operating File (SØF)

The Substructure Operating File (SØF) is a single logical file used to store all data necessary for a complete multi-level substructuring analysis. The SØF may actually reside on one to ten physical files. However, these physical files are chained together to form a single logical file for use in the analysis of larger problems. See Figure 4 showing the basic arrangement of the SØF of disk or drum.

Each physical file comprising the SØF is a direct access disk file. These disk files are not used by NASTRAN GINØ operations. NASTRAN treats them as external user files. In a substructure analysis, NASTRAN stores data on the SØF which must be saved from run to run. Therefore, it is the user's responsibility to maintain the physical disk files comprising the SØF from one execution to the next.

The SØF declaration in the Substructure Control Deck is used to define the physical files which make up the SØF. See Section 2.7 for a complete description of the SØF declaration. An SØF composed of only one physical file which already exists, might be declared as follows:

SØF(1)=SØF1,200,ØLD

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A new SØF composed of five physical files would be declared as follows:

```
SØF(1)=SØF1,200,NEW  
SØF(2)=SØF2,200  
SØF(3)=SØF3,400  
SØF(4)=SØF4,600  
SØF(5)=SØF5,700
```

All data stored on the SØF is accessed via the substructure name. For each substructure, various types of SØF data may be stored. These types of data are called items and are accessed via their item names. Thus, the substructure name and item name are all that is required to access any block of data on the SØF. The items which can be stored for any substructure are described in Table 2. The program automatically keeps track of the data, stores the data as it is created, and retrieves these data when required. The user's only responsibility is to maintain the file. It must be accessible by the system when needed. The user must remove items already created in the event input errors were detected during processing or if that data is no longer needed for subsequent analyses.

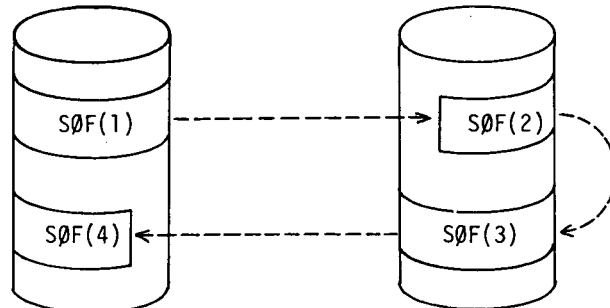


Figure 4. Substructure Operating File (SØF).

1.14.3 The Case Control Deck for Substructuring Analyses

The Case Control Deck controls loading conditions, constraint set selection, output requests, and so forth in a substructuring analysis just as in a non-substructuring analysis. However, in a substructuring analysis, there are very important relationships among the Case Control Decks to be input for the three Phases of a substructuring analysis. Compatibility among the substructuring Phases must be maintained for load sets, constraint sets, and subcase definitions. This section will describe how the Case Control Deck should be used for each of the three Phases.

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1.14.3.1 Phase 1

The following requirements must be satisfied by the Case Control Deck in Phase 1:

1. Constraint set selections (MPC, SPC) must be above the subcase level. That is, only one set of constraints is allowed in Phase 1 for all loading conditions.
2. One subcase must be defined for each loading condition which is to be saved on the SØF. The loading condition may consist of any combination of external static loads, thermal loads, element deformation loads, or enforced displacements. Loading conditions which are not saved on the SØF in Phase 1 cannot be used in any solution in Phase 2.

1.14.3.2 Phase 2

The Phase 2 Case Control Deck is exactly like the Case Control used in a non-substructuring analysis. It is only needed, however, if plots are requested or when there is a SØLVE command in the Substructure Control Deck. In this latter case, the subcase definitions, load and constraint set selections, etc. are used in the usual fashion to control the solution process.

Case Control output requests are honored only if there is a PRINT or SAVE subcommand under the RECØVER command in the Substructure Control Deck. If a RECØVER command with a PRINT or SAVE subcommand is used for a solution obtained in a previous execution, the Case Control should be identical (except for output requests) to that used to obtain that solution.

1.14.3.3 Phase 3

The following requirements must be satisfied by the Case Control Deck in Phase 3:

1. Constraint sets (MPC, SPC) must be identical to those used in Phase 1 for this substructure.
2. The subcase definitions must be identical to those used in Phase 2 for the Phase 2 SØLVE operation. That is, they must conform in number.

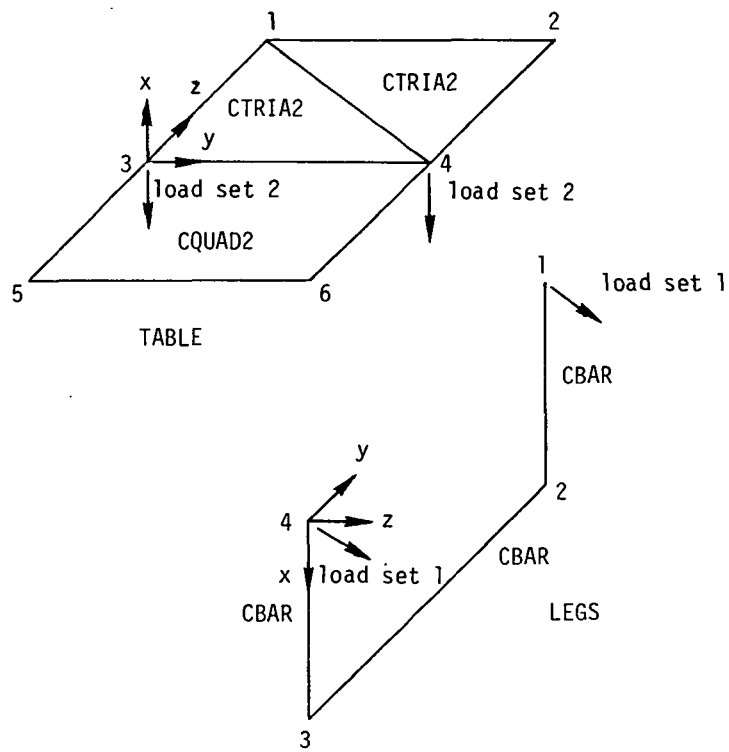
Load set selections are not required in Phase 3 unless there is an ØLOAD output request and the problem is not a Phase 1 restart. If there is such a request, the load set selected for each subcase should be the component of the load used in the Phase 2 solution which originated in this substructure. Note that if the load was scaled in Phase 2, it should be scaled again in Phase 3 (use the 'LØAD' Bulk Data card). Temperature loads should not be scaled in any event, due to limitations in the stress calculation logic.

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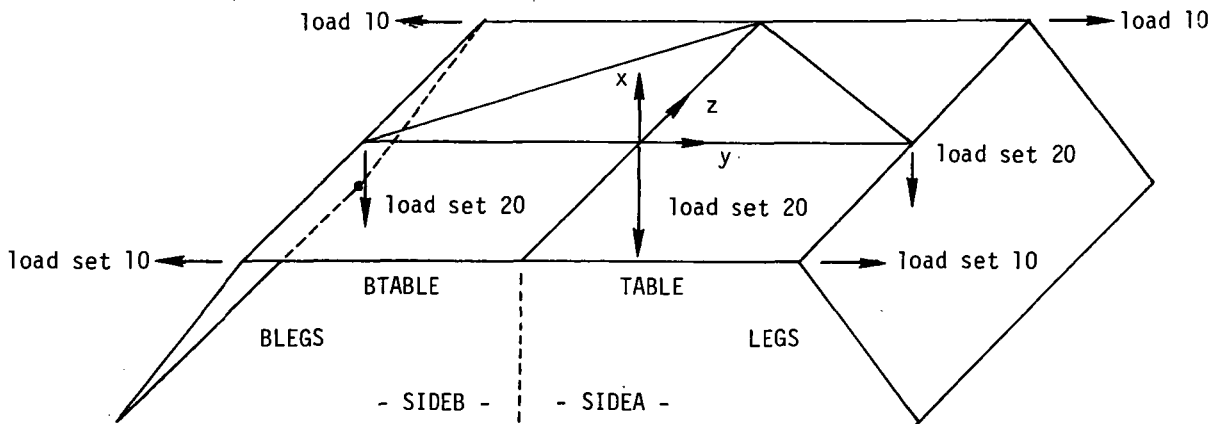
1.14.4 Example of Substructure Analysis

This example illustrates a simple substructuring analysis. Figure 5a shows two basic substructures, TABLE and LEGS. Note that these structures have different basic coordinate systems as shown in the figure. Figure 5b shows a combined structure which is assembled from the basic substructures. The entire data decks to generate and analyze this structure are listed in Tables 3 - 6. These include the data for the generating of the basic substructures in Phase 1, the assembly of the complete structure, solution, and data recovery in Phase 2, and the data recovery in Phase 3. The remainder of this section is devoted to a detailed description of each of the data decks used in this analysis.

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a. Phase 1 basic substructures.



b. Phase 2 combined substructure.

Figure 5. Substructure example problem.

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Table 3. Phase 1 Data Deck for Substructure TABLE.

Card
No.

```

1 ID TABLE,BASIC
2 APP DISP,SUBS
3 SOL 2,0
4 TIME 1
5 CHPNT YES
6 CEND

7 SUBSTRUCTURE PHASE1
8 PASSWORD=PROJECTX
9 SOL(1)=SOLF1,250,NEW
10 NAME=TABLE
11 SAVEPLT=1
12 SOLFPRINT TQC
13 ENDSUBS

14 TITLE=TABLE, PHASE ONE
15 LOAD=2
16 OUTPUT(PLT)
17 SET 1=ALL
18 PLT
19 BEGIN BULK
    
```

	1	2	3	4	5	6	7	8	9	10
20	CQUAD2	3	2	5	6	4	3			
21	CTRIA2	1	1	1	2	4				
22	CTRIA2	2	1	3	4	1				
23	FORCE	2	3		10.0	-1.0				
24	FORCE	2	4		10.0	-1.0				
25	GRID	1		0.0	0.0	5.				
26	GRID	2		0.0	7.	5.				
27	GRID	3		0.0	0.0	0.0				
28	GRID	4		0.0	7.	0.0				
29	GRID	5		0.0	0.0	-5.				
30	GRID	6		0.0	7.	-5.				
31	GRID	7						123456		
32	MAT1	1	3.+7		.3	4.3				
33	PQUAD2	2	1	.1						
34	PTRIA2	1	1	.1						
35	ENDDATA									

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Table 4. Phase 1 Data Deck for Substructure LEGS.

Card
No.

1 ID LEGS,BASIC
2 APP DISP,SUBS
3 SØL 2,0
4 TIME 1
5 CHKPNT YES
6 CEND

7 SUBSTRUCTURE PHASE1
8 PASSWØRD=PRØJECTY
9 SØF(1)=SØF4,7500
10 NAME=LEGS
11 SAVEPLØT=1
12 SØFØUT INP3
13 PØSITION=REWIND
14 NAME=LEGS
15 EDIT(32) LEGS
16 ENDSUBS

17 TITLE=LEGS PHASE ØNE
18 LØAD=1
19 ØUTPUT(PLØT)
20 SET 1=ALL
21 PLØT
22 BEGIN BULK

	1	2	3	4	5	6	7	8	9	10
23	CBAR	1	1	1	2	5			2	
24	CBAR	2	1	3	2	5			2	
25	CBAR	3	1	4	3	5			2	
26	FØRCE	1	1		2.0	3.0	.0	4.0		
27	FØRCE	1	4		2.0	3.0	.0	4.0		
28	GRID	1		0.0	10.	0.0				
29	GRID	2		5.	10.	0.0				
30	GRID	3		5.	0.0	0.0				
31	GRID	4		0.0	0.0	0.0				
32	GRID	5		100.	100.	0.0		123456		
33	MAT1	1	3.+7		.3	4.3				
34	PBAR	1	1	1.0	50.	100.	10.			
35	ENDDATA									

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Table 5. Phase 2 Data Deck.

Card No.	
1	ID SUBSTR,PHASE2
2	APP DISP,SUBS
3	SOL 1,0
4	TIME 1
5	DIAG 23
6	CEND
7	SUBSTRUCTURE PHASE2
8	PASSWORD=PROJECTX
9	SOF(1)=SOF1,250
10	OPTIONS=K,M,P
11	SOFIN INP3,TAPE
12	POSITION=REWIND
13	NAME=LEGS
14	SOFPRINT TQC
15	COMBINE LEGS,TABLE
16	NAME=SIDEA
17	TOLER=0.001
18	OUTPUT=1,2,7,11,12,13,14,15,16,17
19	COMPONENT LEGS
20	TRANS=10
21	EQUIV SIDEA,SIDEB
22	PREFIX=B
23	COMBINE SIDEA,SIDEB
24	NAME=BIGTABLE
25	TOLER=0.001
26	OUTPUT=1,2,7,11,12,13,14,15,16,17
27	COMPONENT SIDEB
28	SYMT=Y
29	REDUCE BIGTABLE
30	NAME=SMALTABL
31	BOUNDARY=100
32	OUTPUT=1,2,3,4,5,6,7,8
33	SOFPRINT TQC
34	PLT SMALTABL
35	SOLVE SMALTABL
36	RECOVER SMALTABL
37	PRINT BIGTABLE
38	SAVE BTABLE
39	SOFPRINT TQC
40	ENDSUBS
41	TITLE=PHASE TWO SUBSTRUCTURE
42	DISP=ALL
43	SPCF=ALL
44	LOAD=ALL
45	SPC=10
46	SUBCASE 1
47	LOAD=10
48	SUBCASE 2
49	LOAD=20
50	OUTPUT(PLT)
51	SET 1=ALL
52	PLT
53	BEGIN BULK

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Table 5. Phase 2 Data Deck (continued)

Card
No.

	1	2	3	4	5	6	7	8	9	10
54	BDYC	100	LEGS	20	BLEGS	20				+A
55	+A		TABLE	10	BTABLE	10				
56	BDYS1	1C	4	1	3	4	5			
57	BDYS1	1C	123456	2	6					
58	BDYS1	20	123456	2	3					
59	LOADC	10	1.0	LEGS	1	1.0	BLEGS	1	1.0	
60	LOADC	20	1.0	TABLE	2	1.0	BTABLE	2	1.0	
61	SPCS1	10	BLEGS	123456	2	3				
62	SPCS1	10	BTABLE	4	1	3	4	5		
63	SPCS1	10	LEGS	123456	2	3				
64	SPCS1	10	TABLE	4	1	3	4	5		
65	TRANS	10		.0	7.0	-5.0	3.0	11.0	-5.0	+B
66	+B	0.0	8.0	-5.0						
67	ENDDATA									

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Table 6. Phase 3 Data Deck.

Card
No.

```
1 ID TABLE,BASIC
2 APP DISP,SUBS
3 SOL 1,0
4 TIME 1
5 RESTART TABLE,BASIC (Restart deck)
6 CEND

7 SUBSTRUCTURE PHASE3
8 PASSWORD=PROJECTX
9 SDF(1)=SDF1,250
10 BRECOVER BTABLE
11 ENDSUBS

12 TITLE=PHASE THREE FOR REFLECTED TABLE
13 DISP=ALL
14 LOAD=ALL
15 SPCF=ALL
16 STRESS=ALL
17 SUBCASE 1
18 SUBCASE 2
19     LOAD=2
20 BEGIN BULK
21 ENDDATA
```

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Phase 1 Data Deck for Substructure TABLE

Card No.	Refer to Table 3 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck <u>except</u> the 'SUBS' option is selected on the APP card.
7	First card of Substructure Control Deck. Phase 1 is selected.
8	Password protection on the SØF is 'PRØJECTX'.
9	The SØF consists of one physical file with an index of one. (Indices must begin with one and increase sequentially.) The name of the file is 'SØF1' and it has a maximum size of 250,000 words. The file is to be initialized. (Internal pointers will be set to indicate that the SØF contains no data.)
10	The basic substructure to be generated will be identified by the name TABLE.
11	Plot set 1 will be saved on the SØF for performing plots of the combined structure in Phase 2.
12	Print a table of contents for the SØF. This includes a list of all substructures and their data items.
13	End of Substructure Control Deck
15	Selects the load to be saved on the SØF for use in Phase 2. Note that multiple loads may be saved by using multiple subcases. In addition to external static loads, thermal loads and element deformation loads may be selected.
16-18	Plot control cards are required if the SAVEPLØT subcommand is used in the Substructure Control Deck. These cards are used to define the plot sets for Phase 2 plotting. It is not necessary that a plot tape be set up in Phase 1.
19-35	Standard NASTRAN Bulk Data Deck. These cards define the mathematical model of the basic substructure.

Phase 1 Data Deck for Substructure LEGS

Card No.	Refer to Table 4 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck <u>except</u> the 'SUBS' option is selected on the APP card.
7	First card of the Substructure Control Deck. Phase 1 is selected.
8	Password protection on the SØF is 'PRØJECTY'.
9	The SØF consists of one physical file with an index of one. (Indices must begin with one and increase sequentially.) The name of the file is 'SØF4' and it has a maximum size of 7,500,000 words. The file has been used previously as an SØF.
10	The basic substructure to be generated will be identified by the name LEGS.
11	Plot set 1 will be saved on the SØF for performing plots of the combined structure in Phase 2.
12-14	After substructure LEGS has been generated and saved on the SØF, it is copied out to user tape INP3.

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Card No.

- 15 All data items for substructure LEGS are removed from the SØF. (The substructure name remains in the SØF directory, however.)
- 16 End of Substructure Control Deck
- 18 Selects the load to be saved on the SØF for use in Phase 2. Note that multiple loads may be saved by using multiple subcases. In addition to external static loads, thermal loads, and element deformation loads may be selected.
- 19-21 Plot control cards are required if the SAVEPLØT subcommand is used in the Substructure Control Deck. These cards are used to define the plot sets for Phase 2 plotting. It is not necessary that a plot tape be set up in Phase 1.
- 22-35 Standard NASTRAN Bulk Data Deck. These cards define the mathematical model of the basic substructure.

Phase 2 Data Deck

Card No.

- Refer to Table 5 for input cards described below.
- 1-6 Standard NASTRAN Executive Control Deck except the 'SUBS' option is selected on the APP card. DIAG 23 requests an echo of the automatic DMAP alters generated.
- 7 First card of the Substructure Control Deck. Phase 2 is selected.
- 8,9 These cards specify the same SØF used in Phase 1 for substructure TABLE.
- 10 The card causes matrix operations to be performed on stiffness, mass, and load matrices. The default for Rigid Format 1 is stiffness and loads only. However, Rigid Format 2 was selected in the Phase 1 decks. This caused all three matrix types to be generated in Phase 1.
- 11-13 Basic substructure LEGS is copied to the SØF from user tape INP3.
- 14 Print the SØF table of contents.
- 15-20 Perform an automatic combination of substructures TABLE and LEGS. The resultant combined pseudostructure will be named SIDEA. The tolerance for connections is 0.001 units. Detailed output is requested (see Substructure Command CØMBINE). The basic coordinate system for substructure LEGS is transformed according to transformation set 10 in the Bulk Data.
- 21,22 Create a new secondary substructure SIDEB which is equivalent to SIDEA. This operation causes image substructures BLEGS and BTABLE to be generated.
- 23-28 Perform an automatic combination of substructures SIDEA and SIDEB. The resultant combined pseudostructure will be named BIGTABLE. The tolerance for connections is 0.001 units. Detailed output is requested. The basic coordinate system for pseudostructure SIDEB is symmetrically transformed about the XZ plane, identified by Y, the axis normal to the plane (sign change for all 'Y' degrees of freedom).
- 29-32 Perform a matrix reduction on the matrices of substructure BIGTABLE. The resultant reduced pseudostructure will be named SMALTABL. The retained degrees of freedom are selected in boundary set 100 in the Bulk Data. Detailed output is requested.
- 33 Print the SØF table of contents.
- 34 Plot pseudostructure SMALTABL. The plot control cards in the Case Control Deck are referenced.

- | <u>No.</u> | |
|------------|--|
| 35 | Perform a static solution of pseudostructure SMALTABL. The constraint sets and selected in the Case Control Deck are used. |
| 36-38 | Recover the displacements of substructures BIGTABL and BTABL from the solution of SMALTABL and save them on the SØF. Also, print the results for substructure BIGTABL. The output requests in the Case Control Deck are referenced when the PRINT subcommand is invoked. |
| 39 | Print the SØF table of contents. |
| 40 | End of the Substructure Control Deck |
| 42-44 | Case Control output requests. Referenced by the PRINT subcommand of the RECOVER command. |
| 45-49 | Constraint and load set selections are referenced by the SØLVE command. |
| 50-52 | Plot control cards are referenced by the PLOT command. |
| 54-58 | These Bulk Data cards define the boundary set of retained degrees of freedom which was selected in the REDUCE operation (cards 29-32). |
| 59-64 | These cards define the loads and constraints selected in the Case Control Deck for the substructure SØLVE operation. |
| 65,66 | These cards define the transformation which is applied to the basic coordinate system of substructure LEGS in the first COMBINE operation (cards 15-20). |

Phase 3 Data Deck for Substructure BTABL

- | <u>Card No.</u> | |
|-----------------|--|
| | Refer to Table 6 for input cards described below. |
| 1-6 | Standard NASTRAN Executive Control Deck <u>except</u> the 'SUBS' option is selected on the AP card. "Card" 5 is actually the Restart deck punched out in Phase 1 for substructure T |
| 7 | First card of the Substructure Control Deck. Phase 3 is selected. |
| 8,9 | These cards specify the same SØF used in Phase 2. |
| 10 | This card causes the data for the image basic substructure BTABL to be copied from the SØF to GINØ data blocks. The data can then be used for data recovery operations, i.e. deformed structure plots, stresses, etc. |
| 11 | End of Substructure Control Deck. |
| 13-16 | Output requests for Phase 3 data recovery. |
| 17-19 | <u>The subcase definitions in Phase 3 must be identical to those used in the SØLVE operation in Phase 2.</u> SPC and MPC constraints in Phase 3 must be the same as those used in Phase 2. Load sets selected in Phase 3 must correspond to those selected in Phase 2 for each case. However, load sets selected in Phase 2 which do not exist for this particular basic substructure can <u>not</u> be selected in Phase 3. See Section 1.14.4 for a more detailed discussion of the Phase 3 Case Control Deck. |

NASTRAN DATA DECK

2.1 GENERAL DESCRIPTION OF DATA DECK

The input deck begins with the required resident operating system control cards. The type and number of these cards will vary with the installation. Instructions for the preparation of these control cards should be obtained from the programming staff at each installation.

The operating system control cards are followed by the NASTRAN Data Deck (see Figure 1), which is constructed in the following order (depending on the particular job requirements):

1. The NASTRAN Card
2. The Executive Control Deck
3. The Substructure Control Deck
4. The Case Control Deck
5. The Bulk Data Deck
6. The INPUT Module Data Card(s)

The NASTRAN card is used to change the default values for certain operational parameters, such as buffer size and machine model number. The NASTRAN card is optional, but, if present, it must be the first card of the NASTRAN Data Deck. The NASTRAN card is a free-field card (similar to cards in the Executive Control Deck). Its format is as follows:

NASTRAN keyword₁ = value, keyword₂ = value, . . .

The most frequently used keywords are as follows:

1. BUFFSIZE - Defines the number of words in a GINØ buffer. Usually this value is standardized at any particular installation. However, the desired value may be different from the default value of 1803 (IBM), 1183 (CDC) and 871 (UNIVAC). In any event, related runs, such as restarts and User Master File runs, must use the same BUFFSIZE for all parts of the runs.
2. CØNFIG - Defines the model number of the configuration for use in timing equations for matrix operations. Entries exist for the following configurations:

<u>MACHINE</u>	<u>CØNFIG</u>	<u>MØDEL NØ.</u>
IBM 360/370	0 (default)	91, 95
	3	50
	4	65
	5	75
	6	85
	7	195
	9	155

NASTRAN DATA DECK

<u>MACHINE</u>	<u>CØNFIG</u>	<u>MØDEL NØ.</u>
CDC 6000	0 (default)	6600
	6	6400
UNIVAC 1100	0 (default)	1108

The machine type is automatically determined by NASTRAN. If the model number is the default, the CØNFIG keyword is not needed on the NASTRAN card. It is important to indicate the proper configuration; otherwise, all time-dependent matrix decisions will be incorrect

3. KØN360 - Defines the number of 32-bit words to release for IBM 360 ØS routines and FØRTRAN buffers. The default is 4096.
4. MØDCØM(i) - Defines a nine-word array for module communications. Currently, only MØDCØM(1) is supported. When MØDCØM(1) = 999999, optimization of passive columns in the symmetric decomposition routine is not used. If MØDCØM(1) = 1, diagnostic statistics from subroutine SDCØMP are printed.
5. HICØRE - Defines the amount of open core available to the user on the UNIVAC 1100 series machines. The user area default is nominally 65K decimal words. The ability to increase this value may be installation limited.
6. FILES - Establishes NASTRAN permanent files as being disk files rather than tape files. The FILES are PØØL, ØPTP, NPTP, UMF, NUMF, PLT1, PLT2, INPT, INP1, INP9. Multiple file names must be enclosed with parentheses such as FILES = (UMF,NPTP).

Additional information for all NASTRAN card options is given in Section 6.3.1 of the Programmer's Manual.

The Executive Control Deck begins with the NASTRAN ID card and ends with the CEND card, as indicated in Figure 1. It identifies the job and the type of solution to be performed. It also declares the general conditions under which the job is to be executed, such as, maximum time allowed, type of system diagnostics desired, restart conditions, and whether or not the job is to be checkpointed. If the job is to be executed with a rigid format, the number of the rigid format is declared along with any alterations to the rigid format that may be desired. If Direct Matrix Abstraction is used, the complete DMAP sequence must appear in the Executive Control Deck. The executive control cards and examples of their use are described in Section 2.2.

GENERAL DESCRIPTION OF DATA DECK

The Substructure Control Deck begins with the SUBSTRUCTURE card and terminates with the ENDSUBS card. It defines the general attributes of the Automated Multi-stage Substructuring capability and establishes the control of the Substructure Operating File (SØF). The command cards are illustrated in Section 2.7.

When Automated Multi-stage Substructuring is not included, then the Case Control Deck begins with the first card following CEND and ends with the card, BEGIN BULK. It defines the subcase structure for the problem, makes selections from the Bulk Data Deck, and makes output requests for printing, punching and plotting. A general discussion of the functions of the Case Control Deck and a detailed description of the cards used in this deck are given in Section 2.3. The special requirements of the Case Control Deck for each rigid format are discussed in Section 3.

The Bulk Data Deck begins with the card following BEGIN BULK and ends with the card preceeding ENDDATA. It contains all of the details of the structural model and the conditions for the solution. The BEGIN BULK and ENDDATA cards must be present even though no new bulk data is being introduced into the problem or all of the bulk data is coming from an alternate source, such as User's Master File or user generated input. The format of the BEGIN BULK card is free field. The ENDDATA card must begin in column 1 or 2. Generally speaking, only one structural model can be defined in the Bulk Data Deck. However, some of the bulk data, such as cards associated with loading conditions, constraints, direct input matrices, transfer functions and thermal fields may exist in multiple sets. All types of data that are available in multiple sets are discussed in Section 2.3.1. Only sets selected in the Case Control Deck will be used in any particular solution.

If the INPUT module is employed, one or two additional FORTRAN data cards are required following the ENDDATA card. For specific cases, see Section 2.6.

Comment cards may be inserted in any of the parts of the NASTRAN Data Deck. These cards are identified by a \$ in column one. Columns 2-72 may contain any desired text.

NASTRAN DATA DECK

Except for the IBM 360/370 series, all NASTRAN data cards must be punched using the character set shown in the table below. The EBCDIC character set may be used on the IBM 360/370 series. Any EBCDIC characters are automatically translated into the character set shown in the table below. The EBCDIC character card punch configurations are shown in parenthesis for the five characters that differ from the standard character set.

Character	Card Punch(s)	Character	Card Punch(s)	EBCDIC Punch(s)
blank	blank	N	11-5	
0	0	Ø	11-6	
1	1	P	11-7	
2	2	Q	11-8	
3	3	R	11-9	
4	4	S	0-2	
5	5	T	0-3	
6	6	U	0-4	
7	7	V	0-5	
8	8	W	0-6	
9	9	X	0-7	
A	12-1	Y	0-8	
B	12-2	Z	0-9	
C	12-3	\$	11-3-8	
D	12-4	/	0-1	
E	12-5	+	12	(12-6-8)*
F	12-6	-	11	
G	12-7	(0-4-8	(12-5-8)*
H	12-8)	12-4-8	(11-5-8)*
I	12-9	'	4-8	(5-8)*
J	11-1	=	3-8	(6-8)*
K	11-2	,	0-3-8	
L	11-3	.	12-3-8	
M	11-4	*	11-4-8	

*IBM 360,370 only.

GENERAL DESCRIPTION OF DATA DECK

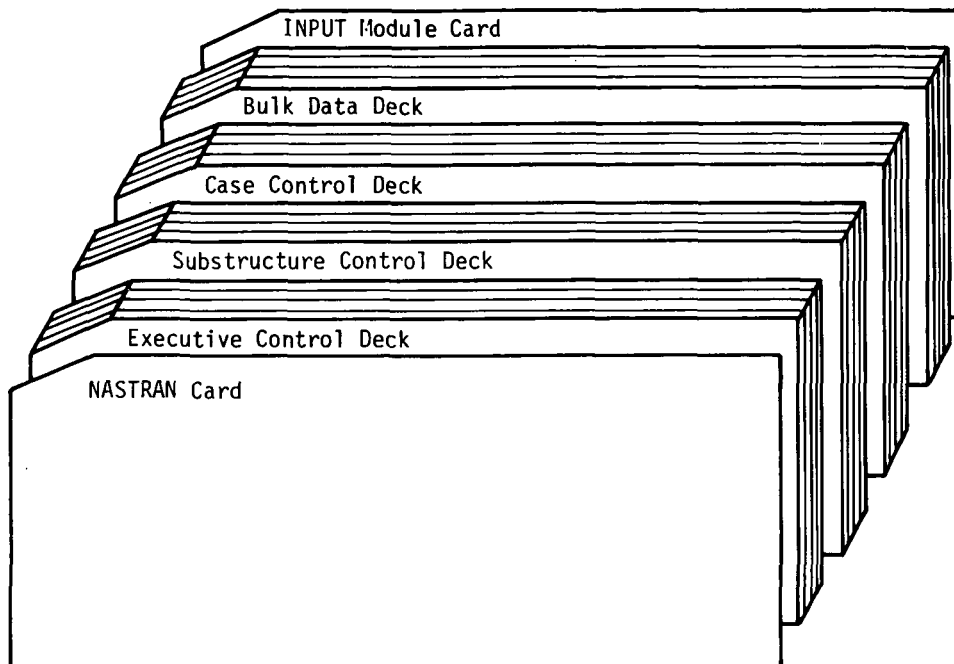


Figure 1. General construction of NASTRAN data deck.

NASTRAN DATA DECK

2.2 EXECUTIVE CONTROL DECK

The format of the Executive control cards is free field. The name of the operation (e.g., CHKPNT) is separated from the operand by one or more blanks. The fields in the operand are separated by commas, and may be up to 8 integers (Ki) or alphanumeric (Ai) as indicated in the following control card descriptions. The first character of an alphanumeric field must be alphabetic followed by up to 7 additional alphanumeric characters. Blank characters may be placed adjacent to separating commas if desired. The individual cards are described in Section 2.2.1 and examples follow in Section 2.2.2.

2.2.1 Executive Control Card Descriptions

ID A1, A2 Required.

A1, A2 -- Any legal alphanumeric fields chosen by the user for problem identification.

RESTART A1, A2, K1/K2/K3, K4, Required for Restart.

A1, A2 -- Fields taken from ID card of previously checkpointed problem.

K1/K2/K3 -- Month/Day/Year that Problem Tape was generated.

K4 -- Number of seconds after midnight at which XCSA begins execution.

The complete restart dictionary consists of this card followed by one card for each file checkpointed. The restart dictionary is automatically punched when operating in the checkpoint mode. All subsequent cards are continuations of this logical card.

Each continuation card begins with a sequence number. Each type of continuation card will be documented separately.

1. Basic continuation card

NO,DATABLOCK,FLAG=Y,REEL=Z,FILE=W

where: NO is the sequence number of the card. The entire dictionary must be in sequence by this number.

DATABLOCK is the name of the data block referenced by this card.

FLAG=Y defines the status of the data block where Y = 0 is the normal case and Y = 4 implies this data block is equivalenced to another data block. In this case (FLAG=4) the file number points to a previous data block which is the "actual" copy of the data.

NASTRAN DATA DECK

REEL=Z specifies the reel number as the Problem Tape can be a multi-reel tape. Z = 1 is the normal case.

FILE=W specifies the GINØ (internal) file number of the data block on the Problem Tape. A zero value indicates the data block is purged. For example:

1,GPL,FLAGS=0,REEL=1,FILE=7 says data block GPL occupies file 7 of reel 1.

2,KGG,FLAGS=4,REEL=1,FILE=20 says KGG is equivalenced to the data block which occupies file 20. (Note that FLAGS=4 cards usually occur in at least pairs as the equivalenced operation is at least binary).

3,USETD,FLAGS=0,REEL=1,FILE=0 implies USETD is purged.

2. Reentry point card:

NO,REENTER AT DMAP SEQUENCE NUMBER N

where: NO is the sequence number of the card.

N is the sequence number associated with the DMAP instruction at which the problem will restart. This value may be changed by adding a final such card (i.e., only the last such card is operative). This may be necessary when restarting from a Rigid Format to a DMAP sequence (to print a matrix for example).

There are four types of restarts Unmodified Restart, Modified Restart, Rigid Format Switch and Pseudo Modified Restart. The function of the reentry point is different in each case. On an unmodified restart the program continues from the reentry point. On a modified restart modules which must be run to process the modified data but which are ahead of the reentry point are executed first. The program then continues from the reentry point. On a Rigid Format Switch (going from a Rigid Format to another) the reentry point is meaningless in that it was determined for another DMAP sequence. In this case the data blocks available are consulted to determine the proper sequence of modules to run. A Pseudo modified restart (defined by the existence of only changes to output producing data such as plotter requests) is treated like a modified restart. The type of restart is implied by the changes made in the NASTRAN Data Deck. No explicit request for a particular kind of restart is required. See Section 3.1 for additional information.

EXECUTIVE CONTROL DECK

3. End of dictionary card

\$ END OF CHECKPOINT DICTONARY

This card is simply a comment card but is punched to signal the end of the dictionary for user convenience. The program does not need such a card. Terminations associated with non-NASTRAN failures (operator intervention, maximum time etc.) will not have such a card punched.

NUMF K1, K2 Required when creating a User's Master File.

K1 -- User specified tape identification number assigned during the creation of a User's Master File.

K2 -- User specified problem identification number assigned during the creation of a User's Master File.

UMF K1, K2 Required when using a User's Master File.

K1 -- Previously assigned tape identification number to access a Bulk Data Deck when using a User's Master File.

K2 -- Previously assigned problem identification number to access a Bulk Data Deck when using a User's Master File.

CHKPNT A1 or CHKPNT A1, A2 Optional.

A1 -- YES if problem is to be checkpointed, NO if problem is not to be checkpointed - default is NO.

A2 -- DISK if checkpoint file is on direct access device. If the DISK option is used, the user must instruct the resident operating system to permanently catalog the checkpoint file.

APP A Required.

A -- DISPLACEMENT indicates one of the Displacement Approach rigid formats.

A -- HEAT indicates one of the Heat Transfer Approach rigid formats.

A -- AERO indicates the Aeroelastic Approach rigid formats.

A -- DMAP indicates Direct Matrix Abstraction Approach (DMAP).

ALTER K1, K2 Optional.

K1, K2 -- First and last DMAP instructions of series to be deleted and replaced with any following DMAP instructions.

ALTER K Optional.

K -- Input any following DMAP instructions after statement K.

ENDALTER Required when using ALTER.

Indicates end of DMAP alterations.

NASTRAN DATA DECK

TIME K Required.

K -- Maximum allowable execution time in minutes.

SOL K1 [,Ki] or SOL An [,Ki] Required when using a rigid format (see Section 3.1 for available options).

K1 -- Solution number of Rigid Format (see table below and Section 3.1).

Ki -- Subset numbers for solution K1, default value = 0. Multiple subsets may be selected by using multiple integers separated by commas.

An -- Name of Rigid Format (see table below)

Displacement Approach Rigid Formats

<u>K1</u>	<u>An</u>
1	STATICS
2	INERTIA RELIEF
3	M0DES or N0RMAL M0DES or REAL EIGENVALUES
4	DIFFERENTIAL STIFFNESS
5	BUCKLING
6	PIECEWISE LINEAR
7	DIRECT COMPLEX EIGENVALUES
8	DIRECT FREQUENCY RESPONSE
9	DIRECT TRANSIENT RESPONSE
10	M0DAL COMPLEX EIGENVALUES
11	M0DAL FREQUENCY RESPONSE
12	M0DAL TRANSIENT RESPONSE
13	N0RMAL M0DES ANALYSIS WITH DIFFERENTIAL STIFFNESS
14	STATICS CYCLIC SYMMETRY
15	M0DES CYCLIC SYMMETRY

Heat Transfer Approach Rigid Formats

<u>K1</u>	<u>An</u>
1	STATICS
3	STEADY STATE
9	TRANSIENT

Aeroelastic Approach Rigid Format

<u>K1</u>	<u>An</u>
10	M0DAL FLUTTER ANALYSIS

Subset Numbers

1. Delete loop control.
2. Delete mode acceleration method of data recovery (modal transient and modal frequency response).
3. Combine subsets 1 and 2.
4. Check all structural and aerodynamic data without execution of the aeroelastic problem.
5. Check only the aerodynamic data without execution of the aeroelastic problem.
6. Delete checkpoint instructions.
7. Delete structure plotting and X-Y plotting.
8. Delete Grid Point Weight Generator.
9. Delete fully stressed design (static analysis).

EXECUTIVE CONTROL DECK

DIAG K Optional request for diagnostic output.

- K = 1 Dump memory when fatal message is generated.
- K = 2 Print File Allocation Table (FIAT) following each call to the File Allocator.
- K = 3 Print status of the Data Pool Dictionary (DPD) following each call to the Data Pool Housekeeper.
- K = 4 Print the Operation Sequence Control Array (OSCAR).
- K = 5 Print BEGIN time on-line for each functional module.
- K = 6 Print END time on-line for each functional module.
- K = 7 Print eigenvalue extraction diagnostics for real and complex determinant methods.
- K = 8 Print matrix and table data block trailers as they are generated.
- K = 9 Suppress echo of checkpoint dictionary.
- K = 10 Use alternate nonlinear loading in TRD. (Replace $\{N_{n+1}\}$ by $\frac{1}{3} \{N_{n+1} + N_n + N_{n-1}\}$)
- K = 11 Print all active row and column possibilities for decomposition algorithms.
- K = 12 Print eigenvalue extraction diagnostics for complex inverse power.
- K = 13 Print open core length.
- K = 14 Print the Rigid Format (NASTRAN SOURCE PROGRAM COMPILATION)
- K = 15 Trace GINØ OPEN/CLØSE operations.
- K = 16 Trace real inverse power eigenvalue extraction operations.
- K = 17 Punch the DMAP sequence that is compiled.
- K = 18 Trace Heat Transfer iterations (APP HEAT) or print grid point ID conversions from SET card (APP AERØ).
- K = 19 Print data for MPYAD method selection.
- K = 20 Generate de-bug printout (For NASTRAN programmers who include CALL BUG in their subroutines).
- K = 21 Print GP4 set definition.
- K = 22 Print GP4 degree of freedom definition.
- K = 23 Print the DMAP alters generated during Automated Multi-stage Substructuring.
- K = 24 Punch the DMAP alters generated during Automated Multi-stage Substructuring.
- K = 25
- K = 26
- K = 27 Input File Processor (IFP) table dump.
- K = 28 Punch the link specification table (Deck XBSBD).
- K = 29 Process link specification table update deck.

EXECUTIVE CONTROL DECK

K = 30 Punch alters to the XSEMI decks (i set via DIAG 1-15).

K = 31 Print link specification table and module properties list data.

Multiple options may be selected by using multiple integers separated by commas. Other options and other rules associated with the DIAG card which primarily concern the programmer can be found in Section 6.11.3 of the Programmer's Manual.

BEGIN\$ Required when using DMAP approach.

Indicates beginning of DMAP sequence. This card is supplied as part of a Rigid Format.

END\$ Required when using DMAP approach.

Indicates end of DMAP sequence. This card is supplied as part of a Rigid Format.

UMFEDIT Required when using User's Master File Editor (see Section 2.5)

\$ Comment flag in column 1. Commentary text may appear in columns 2-80.

NASTRAN DATA DECK

CEND Required

Indicates end of Executive control cards.

The ID card must appear first and CEND must be the last card of the Executive Control Deck. Otherwise the Executive Control card groups (RESTART dictionary, DMAP sequence, ALTER packet) can be in any order.

2.2.2 Executive Control Deck Examples

1. Cold start, no checkpoint, rigid format, diagnostic output.

```
ID      MYNAME, BRIDGE23
APP     DISPLACEMENT
SØL     2,0
TIME    5
DIAG    1,2
CEND
```

2. Cold start, checkpoint, rigid format.

```
ID      PERSØNZZ, SPACECFT
CHKPNT  YES
APP     DISPLACEMENT
SØL     1,3
TIME    15
CEND
```

3. Restart, no checkpoint, rigid format. The restart dictionary indicated by the brace is automatically punched on previous run in which the CHKPNT option was selected by the user.

```
ID JØESHMØE, PRØJECTX
{ RESTART PERSØNZZ, SPACECFT, 05/13/67,
  1, XVPS, FLAGS=0, REEL=1, FILE=6
  2, REENTER AT DMAP SEQUENCE NUMBER 7
  3, GPL, FLAGS=0 REEL=1, FILE=7
  .
  .
  .
$ END OF CHECKPØINT DICTIØNARY
APP     DISPLACEMENT
SØL     3,3
TIME    10
CEND
```

EXECUTIVE CONTROL DECK

4. Cold start, no checkpoint, DMAP. User-written DMAP program is indicated by braces.

```

ID          IAM007, TRYIT
APP          DMAP
BEGIN $

{DMAP statements go here}

END $
TIME        8
CEND

```

5. Restart, checkpoint, altered rigid format, diagnostic output.

```

ID GØØDGUY, NEATDEAL
{
  RESTART BADGUY, NØSHOW, 05/09/68,
    1, XVPS, FLAGS=0, REEL=1, FILE=6
    2, REENTER AT DMAP SEQUENCE NUMBER 7
    3, GPL, FLAGS=0, REEL=1, FILE=7
    .
    .
    .
}
$ END ØF CHECKPØINT DICTIØNARY

CHKPNT      YES
DIAG         2,4
APP          DISPLACEMENT
SØL          3,3
TIME         15
ALTER        20
MATPRN       KGGX,,,// $
TABPT        GPST,,,// $
ENDALTER
CEND

```

NASTRAN DATA DECK

2.3 CASE CONTROL DECK

2.3.1 Data Selection

The case control cards that are used for selecting items from the Bulk Data Deck are listed below in functional groups. A detailed description of each card is given in Section 2.3.4. The first four characters of the mnemonic are sufficient if unique.

The following case control cards are associated with the selection of applied loads for both static and dynamic analysis:

1. DEFØRM - selects element deformation set.
2. DLØAD - selects dynamic loading condition.
3. DSCØEFFICIENT - selects loading increments for static analysis with differential stiffness.
4. LØAD - selects static loading condition.
5. NØNLINEAR - selects nonlinear loading condition for transient response.
6. PLCØEFFICIENT - selects loading increments for piecewise linear analysis.

The following case control cards are used for the selection of constraints:

1. AXISYMMETRIC - selects boundary conditions for conical shell and axisymmetric solid elements or specifies the existence of fluid harmonics for a hydroelastic problem.
2. MPC - selects set of multipoint constraints.
3. SPC - selects set of single-point constraints.

The following case control cards are used for the selection of direct input matrices:

1. B2PP - selects direct input damping matrices.
2. K2PP - selects direct input stiffness matrices.
3. M2PP - selects direct input mass matrices.
4. TFL - selects transfer functions.

The following case control cards specify the conditions for dynamic analyses:

1. CMETHØD - selects the conditions for complex eigenvalue extraction.
2. FREQUENCY - selects the frequencies to be used for frequency and random response calculations.
3. IC - selects the initial conditions for direct transient response.
4. METHØD - selects the conditions for real eigenvalue analysis.
5. RANDØM - selects the power spectral density functions to be used in random analysis.

NASTRAN DATA DECK

6. SDAMPING - selects table to be used for determination of modal damping.
7. TSTEP - selects time steps to be used for integration in transient response problems.
8. FMETHØD - selects method to be used in aeroelastic flutter analysis.

The following case control cards are associated with the use of thermal fields:

1. TEMPERATURE(LØAD) - selects thermal field to be used for determining equivalent static loads.
2. TEMPERATURE(MATERIAL) - selects thermal field to be used for determining material properties.
3. TEMPERATURE - selects thermal field for determining both equivalent static loads and material properties.

2.3.2 Output Selection

Printer output requests may be grouped in packets following ØUTPUT cards or the individual requests may be placed anywhere in the Case Control Deck ahead of any structure plotter or curve plotter requests. Plotter requests are described in Section 4. The case control cards that are used for output selection are listed below in functional groups. A detailed description of each card is given in Section 2.3.4.

The following cards are associated with output control, titling and bulk data echoes:

1. TITLE - defines a text to be printed on first line of each page of output.
2. SUBTITLE - defines a text to be printed on second line of each page of output.
3. LABEL - defines a text to be printed on third line of each page of output.
4. LINE - sets the number of data lines per printed page, default is 50 for 11-inch paper.
5. MAXLINES - sets the maximum number of output lines, default is 20,000.
6. ECHØ - selects echo options for Bulk Data Deck, default is a sorted bulk data echo.

The following cards are used in connection with some of the specific output requests for calculated quantities:

1. SET - defines lists of point numbers, elements numbers, or frequencies for use in output requests.
2. ØFREQUENCY - selects a set of frequencies to be used for output requests in frequency response problems; default is all frequencies used in the calculations.
3. TSTEP - selects a set of time steps to be used for output requests in transient response problems.

CASE CONTROL DECK

The following cards are used to make output requests for the calculated response of components in the SOLUTION set (components in the direct or modal formulation of the general K system) for dynamics problems:

1. SACCELERATION - requests the acceleration of the independent components for a selected set of points or modal coordinates.
2. SDISPLACEMENT - requests the displacements of the independent components for a selected set of points or modal coordinates or the temperatures of the independent components for a selected set of points in heat transfer.
3. SVELOCITY - requests the velocities of the independent components for a selected set of points or modal coordinates or the change in temperature with respect to time of the independent components for a selected set of points in heat transfer.
4. NLLLOAD - requests the nonlinear loads for a selected set of physical points (grid points and extra points introduced for dynamic analysis) intransient response problems.

The following cards are used to make output requests for stresses and forces, as well as the calculated response of degrees of freedom used in the model:

1. ELFORCE - requests the forces in a set of structural elements or the temperature gradients and fluxes in a set of structural or heat elements in heat transfer.
2. STRESS - requests the stresses in a set of structural elements or the velocity components in a fluid element in acoustic cavity analysis.
3. SPCFORCES - requests the single-point forces of constraint at a set of points or the thermal power transmitted at a selected set of points in heat transfer.
4. LOADAD - selects a set of applied loads for output.
5. ACCELERATION - requests the accelerations for a selected set of PHYSICAL points (grid, scalar and fluid points plus extra points introduced for dynamic analysis).
6. DISPLACEMENT - requests the displacements for a selected set of PHYSICAL points or the temperatures for a selected set of PHYSICAL points in heat transfer or the pressures for a selected set of PHYSICAL points in hydroelasticity.
7. VELOCITY - requests the velocities for a selected set of PHYSICAL points or the change in temperatures with respect to time for a selected set of PHYSICAL points in heat transfer.
8. HARMONICS - controls the number of harmonics that will be output for requests associated with the conical shell, axisymmetric solids and hydroelastic problems.
9. ESE - requests structural element strain energies in Rigid Format 1.
10. GPFORCE - requests grid point force balance due to element forces, forces of single point constraint, and applied loads in Rigid Format 1.
11. THERMAL - requests temperatures for a set of PHYSICAL points in heat transfer.
12. PRESSURE - requests pressures for a set of PHYSICAL points in hydroelasticity.

2.3.3 Subcase Definition

In general, a separate subcase is defined for each loading condition. In statics problems separate subcases are also defined for each set of constraints. In complex eigenvalue analysis

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and frequency response separate subcases are defined for each unique set of direct input matrices. Subcases may be used in connection with output requests, such as in requesting different output for each mode in a real eigenvalue problem.

The Case Control Deck is structured so that a minimum amount of repetition is required. Only one level of subcase definition is provided. All items placed above the subcase level (ahead of the first subcase) will be used for all following subcases, unless overridden within the individual subcase.

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In static problems, provision has been made for the combination of the results of several subcases. This is convenient for studying various combinations of individual loading conditions, and for the superposition of solutions for symmetrical and antisymmetrical boundaries.

Typical examples of subcase definition are given following a brief description of the cards used in subcase definitions.

The following case control cards are associated with subcase definition:

1. SUBCASE - defines the beginning of a subcase that is terminated by the next subcase delimiters encountered.
2. SUBCØM - defines a combination of two or more immediately preceeding subcases in statics problems. Output requests above the subcase level are used.
3. SUBSEQ - must appear in a subcase defined by SUBCØM to give the coefficients for making the linear combination of the preceeding subcases.
4. SYM - defines a subcase in statics problems for which only output requests within the subcase will be honored. Primarily for use with symmetry problems where the individual parts of the solution may not be of interest.
5. SYMCØM - defines a combination of two or more immediately preceeding SYM subcases in static problems. Output requests above the subcase level are used.
6. SYMSEQ - may appear in a subcase defined by SYMCØM to give the coefficient for making the linear combination of the preceeding SYM subcases. A default value of 1.0 is used if no SYMSEQ card appears.
7. REPCASE - defines a subcase in statics problems that is used to make additional output requests for the previous real subcase. This card is required because multiple output requests for the same item are not permitted in the same subcase. Output requests above the subcase level are still used.
8. MØDES - repeats the subcase in which it appears MØDES times for eigenvalue problems. Used to repeat the same output request for several consecutive modes.

The following examples of Case Control Decks indicate typical ways of defining subcases:

1. Static analysis with multiple loads.

```
ØOUTPUT
DISPLACEMENT = ALL
MPC = 3
SUBCASE 1
  SPC = 2
  TEMPERATURE(LØAD) = 101
  LØAD = 11
SUBCASE 2
  SPC = 2
  DEFØRM = 52
  LØAD = 12
SUBCASE 3
  SPC = 4
  LØAD = 12
SUBCASE 4
  MPC = 4
  SPC = 4
```

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Four subcases are defined in this example. The displacements at all grid points will be printed for all four subcases. MPC = 3 will be used for the first three subcases and will be overridden by MPC = 4 in the last subcase. Since the constraints are the same for subcases 1 and 2 and the subcases are contiguous, the static solutions will be performed simultaneously. In subcase 1, thermal load 101 and external load 11 are internally superimposed, as are the external and deformation loads in subcase 2. In subcase 4 the static loading will result entirely from enforced displacements of grid points.

2. Linear combination of subcases.

```
SPC = 2
ØUTPUT
  SET 1 = 1 THRU 10,20,30
  DISPLACEMENT = ALL
  STRESS = 1
SUBCASE 1
  LØAD = 101
  ØLØAD = ALL
SUBCASE 2
  LØAD = 201
  ØLØAD = ALL
SUBCØM 51
  SUBSEQ = 1.0,1.0
SUBCØM 52
  SUBSEQ = 2.5,1.5
```

Two static loading conditions are defined in subcases 1 and 2. SUBCØM 51 defines the sum of subcases 1 and 2. SUBCØM 52 defines a linear combination consisting of 2.5 times subcase 1 plus 1.5 times subcase 2. The displacements at all grid points and the stresses for the elements numbers in SET will be printed for all four subcases. In addition, the nonzero components of the static load vectors will be printed for subcases 1 and 2.

3. Statics problem with one plane of symmetry.

```
ØUTPUT
  SET 1 = 1,11,21,31,51
  SET 2 = 1 THRU 10, 101 THRU 110
  DISPLACEMENT = 1
  ELFORCE = 2
SYM 1
  SPC = 11
  LØAD = 21
  ØLØAD = ALL
SYM 2
  SPC = 12
  LØAD = 22
SYMCØM 3
SYMCØM 4
  SYMSEQ 1.0,-1.0
```

Two SYM subcases are defined in subcases 1 and 2. SYMCØM 3 defines the sum and SYMCØM 4 the

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difference of the two SYM subcases. The nonzero components of the static load will be printed for subcase 1 and no output is requested for subcase 2. The displacements for the grid point numbers in set 1 and the forces for elements in set 2 will be printed for subcases 3 and 4.

4. Use of REPCASE in statics problems.

```
SET 1 = 1 THRU 10, 101 THRU 110, 201 THRU 210
SET 2 = 21 THRU 30, 121 THRU 130, 221 THRU 230
SET 3 = 31 THRU 40, 131 THRU 140, 231 THRU 240
SUBCASE 1
  LOAD = 10
  SPC = 11
  DISPLACEMENT = ALL
  SPCFORCE = 1
  ELFORCE = 1
REPCASE 2
  ELFORCE = 2
REPCASE 3
  ELFORCE = 3
```

This example defines one subcase for solution and two subcases for output control. The displacements at all grid points and the nonzero components of the single-point forces of constraint along with forces for the elements in SET 1 will be printed for SUBCASE 1. The forces for elements in SET 2 will be printed for REPCASE 2 and the forces for elements in SET 3 will be printed for REPCASE 3.

5. Use of MØDES in eigenvalue problems

```
METHØD = 2
SPC = 10
SUBCASE 1
  DISPLACEMENT = ALL
  STRESS = ALL
  MØDES = 2
SUBCASE 3
  DISPLACEMENT = ALL
```

In this example the displacements at all grid points will be printed for all modes. The stresses in all elements will be printed for the first two modes.

2.3.4 Case Control Card Descriptions

The format of the case control cards is free-field. In presenting general formats for each card embodying all options, the following conventions are used:

1. Upper-case letters and parentheses must be punched as shown.
2. Lower-case letters indicate that a substitution must be made.
3. Braces { } indicate that a choice of contents is mandatory.

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4. Brackets [] contain an option that may be omitted or included by the user.
5. Underlined options or values are the default values.
6. Physical card consists of information punched in columns 1 thru 72 of a card. Most case control cards are limited to a single physical card.
7. Logical card may have more than 72 columns with the use of continuation cards. A continuation card is honored by ending the preceeding card with a comma.

The structure plotter output request packet and the x-y output request packet, while part of the Case Control Deck, are treated separately in Sections 4.2 and 4.3, respectively.

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Case Control Data Card - ACCELERATION - Acceleration Output Request.

Description: Requests form and type of acceleration vector output.

Format and Example(s):

$$\text{ACCELERATION} \left[\begin{pmatrix} \text{SORT1} & \text{PRINT} & \text{REAL} \\ \text{SORT2} & \text{PUNCH} & \text{IMAG} \\ & & \text{PHASE} \end{pmatrix} \right] = \left\{ \begin{matrix} \text{ALL} \\ n \\ \text{NONE} \end{matrix} \right\}$$

ACCELERATION = 5

ACCELERATION(SORT2, PHASE) = ALL

ACCELERATION(SORT1, PRINT, PUNCH, PHASE) = 17

<u>Option</u>	<u>Meaning</u>
SORT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SORT1 is not available in Transient problems (where the default is SORT2).
SORT2	Output will be presented as a tabular listing of frequency or time for each grid point. SORT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Frequency Response problems.
ALL	Accelerations for all points will be output.
n	Set identification of a previously appearing SET card. Only accelerations of points whose identification numbers appear on this SET card will be output (Integer > 0).
NONE	Accelerations for no points will be output.

- Remarks:
1. Both PRINT and PUNCH may be requested.
 2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 3. Acceleration output is only available for Transient and Frequency Response problems.
 4. In a frequency Response problem any request for SORT2 output causes all output to be SORT2.
 5. ACCELERATION = NONE allows overriding an overall output request.

CASE CONTROL DECK

Case Control Data Card AXISYMMETRIC - Boundary Conditions or Hydroelastic Harmonics.

Description: Selects boundary conditons for problems containing CCØNEAX, CTRAPAX or CTRIAAX elements or specifies the existence of fluid harmonics for hydroelastic problems.

Format and Example(s):

AXISYMMETRIC = $\left\{ \begin{array}{l} \text{SINE} \\ \text{CØSINE} \\ \text{FLUID} \end{array} \right\}$

AXISYMMETRIC = CØSINE

<u>Option</u>	<u>Meaning</u>
SINE	Sine boundary conditions will be used.
CØSINE	Cosine boundary conditions will be used.
FLUID	Existence of fluid harmonics.

- Remarks:
1. This card is required for problems containing the elements named above.
 2. If this card is used for hydroelastic problems, at least one harmonic must be specified on the AXIF card.
 3. See Section 1.3.6 of User's Manual for a discussion of the conical shell problem.
 4. See Section 1.3.7 of User's Manual for a discussion of the axisymmetric solid problem.
 5. See Section 1.7.1 of User's Manual for a discussion of the hydroelastic formulation.
 6. The sine boundary condition will constrain components 1, 3 and 5 at every ring for the zero harmonic.
 7. The consine boundary condition will constrain components 2, 4 and 6 at every ring for the zero harmonic.
 8. SPC and MPC case control cards may also be used to effect additional constraints.

NASTRAN DATA DECK

Case Control Data Card B2PP - Direct Input Damping Matrix Selection.

Description: Selects a direct input damping matrix.

Format and Example(s):

B2PP = name
B2PP = BDMIG
B2PP = B2PP

Option

Meaning

name BCD name of $[B_{pp}^2]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. B2PP is used only in dynamics problems.

2. DMIG and DMIAX matrices will not be used unless selected.

CASE CONTROL DECK

Case Control Data Card CMETHØD - Complex Eigenvalue Extraction Method Selection.

Description: Selects complex eigenvalue extraction data to be used by module CEAD.

Format and Example(s):

CMETHØD = n
CMETHØD = 77

Option

Meaning

n Set identification of EIGC (and EIGP) card (Integer > 0).

Remarks: Eigenvalue extraction data must be selected when extracting complex eigenvalues using Functional Module CEAD.

NASTRAN DATA DECK

Case Control Data Card DEFØRM - Element Deformation Static Load.

Description: Selects the Element Deformation Set to be applied to the structural model.

Format and Example(s):

DEFØRM = n

DEFØRM = 27

Option

Meaning

n Set identification of DEFØRM cards (Integer > 0).

- Remarks:
1. DEFØRM bulk data cards will not be used unless selected in the Case Control Deck.
 2. DEFØRM is only applicable in statics, inertia relief, differential stiffness, and buckling problems.
 3. The total load applied will be the sum of external, (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement loads (SPC).
 4. Static, thermal and element deformation loads should have unique identification numbers.

CASE CONTROL DECK

Case Control Data Card DISPLACEMENT - Displacement Output Request.

Description: Requests form and type of displacement vector output.

Format and Example(s):

$$\text{DISPLACEMENT} \left[\begin{pmatrix} \text{SØRT1} & \text{PRINT} & \text{REAL} \\ \text{SØRT2} & \text{PUNCH} & \text{IMAG} \\ & & \text{PHASE} \end{pmatrix} \right] = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NONE} \end{Bmatrix}$$

DISPLACEMENT = 5

DISPLACEMENT(REAL) = ALL

DISPLACEMENT(SØRT2, PUNCH, REAL) = ALL

Option

Meaning

SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each grid point. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ \leq \text{phase} < 360.0^\circ$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points will be output.
NØNE	Displacements for no points will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

- Remarks:
- Both PRINT AND PUNCH may be requested.
 - An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 - In Static Analysis or Frequency Response problems, any request for SØRT2 causes all output to be SØRT2.
 - VECTØR, PRESSURE and THERMAL are alternate forms and are entirely equivalent to DISPLACEMENT.
 - DISPLACEMENT = NØNE allows overriding an overall output request.

NASTRAN DATA DECK

Case Control Data Card DLØAD - Dynamic Load Set Selection.

Description: Selects the dynamic load to be applied in a Transient or Frequency Response problem.

Format and Example(s):

DLØAD = n

DLØAD = 73

Option

Meaning

n	Set identification of a DLØAD, RLØAD1, RLØAD2, TLØAD1, or TLØAD2 card (Integer > 0).
---	--

Remarks:

1. The above loads will not be used by NASTRAN unless selected in Case Control.
2. RLØAD1 and RLØAD2 may only be selected in a Frequency Response problem.
3. TLØAD1 and TLØAD2 may only be selected in a Transient Response problem.

CASE CONTROL DECK

Case Control Data Card DSCØEFFICIENT - Differential Stiffness Coefficient Set.

Description: Selects the coefficient set for a Differential Stiffness problem.

Format and Example(s):

DSCØEFFICIENT = $\left\{ \begin{array}{c} \text{DEFAULT} \\ n \end{array} \right\}$
DSCØEF = 15
DSCØEF = DEFAULT

<u>Option</u>	<u>Meaning</u>
DEFAULT	A single default coefficient of value 1.0.
n	Set identification of DSFACT card (Integer > 0).

Remarks: 1. DSFACT cards will not be used unless selected.
2. DSCØEFFICIENT must appear in the 2nd Subcase of a differential stiffness problem.

NASTRAN DATA DECK

Case Control Data Card ECHØ - Bulk Data Echo Request.

Description: Requests echo of bulk data deck.

Format and Example(s):

ECHØ =

SØRT
UNSØRT
BØTH
NØNE
PUNCH

ECHØ = BØTH

ECHØ = PUNCH, SØRT

Option

Meaning

SØRT	Sorted echo will be printed.
UNSØRT	Unsorted echo will be printed.
BØTH	Both sorted and unsorted echo will be printed.
NØNE	No echo will be printed.
PUNCH	The sorted bulk data deck will be punched onto cards.

- REMARKS:
1. If no ECHØ card appears a sorted echo will be printed.
 2. If CHPNT YES a sorted echo will be printed unless ECHØ = NØNE.
 3. Unrecognizable options will be treated as SØRT.
 4. Any option overrides the default. Thus, for example, if both print and punch are desired, both SØRT and PUNCH must be requested on the same card.

CASE CONTROL DECK

Case Control Data Card ELFØRCE - Element Force Output Request.

Description: Requests form and type of element force output.

Format and Example(s):

$$\text{ELFØRCE} \left[\left(\begin{array}{ccc} \text{SØRT1} & \text{PRINT} & \text{REAL} \\ \text{SØRT2} & \text{PUNCH} & \text{IMAG} \\ & & \text{PHASE} \end{array} \right) \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NØNE} \end{array} \right\}$$

ELFØRCE = ALL

ELFØRCE(REAL, PUNCH, PRINT) = 17

ELFØRCE = 25

Option

Meaning

SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for all elements will be output.
NØNE	Forces for no elements will be output.
n	Set identification of a previously appearing SET card. Only forces of elements whose identification numbers appear on this SET card will be output (Integer > 0).

- Remarks:
- Both PRINT and PUNCH may be requested.
 - An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 - In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
 - FØRCE is an alternate form and is entirely equivalent to ELFØRCE.
 - ELFØRCE = NØNE allows overriding an overall request.

NASTRAN DATA DECK

Case Control Data Card ELSTRESS - Element Stress Output Request.

Description: Requests form and type of element stress output.

Format and Example(s):

$$\text{ELSTRESS} \quad \left[\begin{pmatrix} \text{SØRT1} & \text{PRINT} & \text{REAL} \\ \text{SØRT2} & \text{PUNCH} & \text{IMAG} \\ & & \text{PHASE} \end{pmatrix} \right] = \left\{ \begin{matrix} \text{ALL} \\ n \\ \text{NØNE} \end{matrix} \right\}$$

ELSTRESS = 5

ELSTRESS = ALL

ELSTRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

<u>Option</u>	<u>Meaning</u>
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stress for no elements will be output.

- Remarks:
- Both PRINT and PUNCH may be requested.
 - An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 - In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
 - STRESS is an alternate form and is entirely equivalent to ELSTRESS.
 - ELSTRESS = NØNE allows overriding an overall output request.

CASE CONTROL DECK

Case Control Data Card ESE - Element Strain Energy Output Request

Description: Requests strain energy output and per cent of total strain energy with respect to all elements.

Format and Example(s):

$$\text{ESE} \begin{bmatrix} \text{PRINT} \\ \text{PUNCH} \end{bmatrix} = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NONE} \end{Bmatrix}$$

ESE (PUNCH) = 5

ESE (PRINT,PUNCH) = ALL

Option

Meaning

PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Strain energies will be output for all elements for which stiffness matrices exist.
NONE	Strain energies for no elements will be output.
n	Set identification of previously appearing SET card (Integer >0). Only strain energies for elements whose identification numbers appear on this SET card will be output.

- Remarks:
1. Element strain energies are output from Static Analysis (Rigid Format 1) only.
 2. The output will be in SORT 1 format.
 3. Both PRINT and PUNCH may be requested.
 4. ESE = NONE allows overriding an overall output request.

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Case Control Data Card FMETHØD -Flutter Analysis Method

Description: Selects the FLUTTER parameters to be used by the flutter module (FA1).

Format and Example(s):

FMETHØD = n

FMETHØD = 72

Option

Meaning

n

Set identification number of a FLUTTER card (integer > 0).

Remarks:

A FMETHØD card is required for flutter analysis.

CASE CONTROL DECK

Case Control Data Card FØRCE - Element Force Output Request.

Description: Requests form and type of element force output.

Format and Example(s):

$$FØRCE \left[\left(\begin{matrix} SØRT1 & PRINT & REAL \\ SØRT2 & PUNCH & IMAG \\ & & PHASE \end{matrix} \right) \right] = \left\{ \begin{matrix} ALL \\ n \\ NØNE \end{matrix} \right\}$$

FØRCE = ALL

FØRCE(REAL, PUNCH, PRINT) = 17

FØRCE = 25

<u>Option</u>	<u>Meaning</u>
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for ALL elements will be output.
n	Set identification of a previously appearing SET card. Only forces whose element identification numbers appear on this SET card will be output (Integer > 0).
NØNE	Forces for no elements will be output.

- Remarks:
- Both PRINT and PUNCH may be requested.
 - An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 - In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
 - ELFØRCE is an alternate form and is entirely equivalent to FØRCE.
 - FØRCE = NØNE allows overriding an overall request.

NASTRAN DATA DECK

Case Control Data Card FREQUENCY - Frequency Set Selection

Description: Selects the set of frequencies to be solved in Frequency Response problems.

Format and Example(s):

FREQUENCY = n

FREQUENCY = 17

Option

Meaning

n Set identification of a FREQ, FREQ1 or FREQ2 type card (Integer > 0).

Remarks: 1. The FREQ, FREQ1 or FREQ2 cards will not be used unless selected in Case Control.
2. A frequency set selection is required for a Frequency Response problem.

CASE CONTROL DECK

Case Control Data Card GPFØRCE - Grid Point Force Balance Output Request

Description: Requests grid point force balance output from applied loads, single-point constraints, and element constraints.

Format and Example (s):

$$\text{GPFØ} = \left[\begin{array}{c} \text{PRINT} \\ \text{PUNCH} \end{array} \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NØNE} \end{array} \right\}$$

<u>Option</u>	<u>Meaning</u>
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Force balance will be output for all elements connected to grid points or scalar points.
NØNE	Force balance for no grid points will be output.
n	Set identification of previously appearing SET card (Integer >0). Only force balance for points whose identification numbers appear on this SET card will be output.

- Remarks:
1. Grid point force balance is output from Statics Analysis (Rigid Format 1) only.
 2. The output will be in SØRT 1 format.
 3. Both PRINT and PUNCH may be requested.
 4. GPFØ = NØNE allows overriding an overall output request.

CASE CONTROL DECK-

Case Control Data Card HARMONICS - Harmonic Printout Control.

Description: Controls number of harmonics output for problems containing CCONEAX, CTRAPAX or CTRIAAX elements.

Format and Example(s):

HARMONICS = $\left\{ \begin{array}{c} \text{ALL} \\ \text{NONE} \\ n \\ \underline{0} \end{array} \right\}$

Option

Meaning

ALL All Harmonics will be output.

NONE No Harmonics will be output.

n Available harmonics up to and including n will be output (Integer ≥ 0).

Remarks: If no HARMONICS card appears in Case Control, only 0 harmonic output will be printed.

NASTRAN DATA DECK

Case Control Data Card IC - Transient Initial Condition Set Selection.

Description: To select the initial conditions for Direct Transient problems.

Format and Example(s):

IC = n

IC = 17

<u>Option</u>	<u>Meaning</u>
n	Set identification of TIC card (Integer > 0).

Remarks:

1. TIC cards will not be used (hence no initial conditions) unless selected in Case Control.
2. Initial conditions are not allowed in a Modal Transient problem.

CASE CONTROL DECK

Case Control Data Card K2PP - Direct Input Stiffness Matrix Selection.

Description: Selects a direct input stiffness matrix.

Format and Example(s):

K2PP = name
K2PP = KDMIG
K2PP = K2PP

Option

Meaning

name BCD name of a $[K_{pp}^{2d}]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. K2PP is used only in dynamics problems.
2. DMIG and DMIAX matrices will not be used unless selected.

NASTRAN DATA DECK

Case Control Data Card LABEL - Output Label.

Description: Defines a BCD label which will appear on the third heading line of each page of NASTRAN printer output.

Format and Example(s):

LABEL = { Any BCD data }

LABEL = STEVEN E. WALL'S PROBLEM

- Remarks:
1. LABEL appearing at the subcase level will label output for that subcase only.
 2. LABEL appearing before all subcases will label any outputs which are not subcase dependent.
 3. If no LABEL card is supplied, the label line will be blank.
 4. LABEL information is also placed on NASTRAN plotter output as applicable.

CASE CONTROL DECK

Case Control Data Card LINE - Data Lines Per Page.

Description: Defines the number of data lines per printed page.

Format and Example(s):

LINE = $\left\{ \frac{50}{n} \right\}$ IBM or CDC

LINE = $\left\{ \frac{45}{n} \right\}$ UNIVAC

LINE = 35

Option

Meaning

n Number of data lines per page (Integer > 0).

Remarks: 1. If no LINE card appears, the appropriate default is used.

2. For 11 inch paper, 50 is the recommended number; for 8-1/2 paper, 35 is the recommended number.

NASTRAN DATA DECK

Case Control Data Card LØAD - External Static Load Set Selection.

Description: Selects the external static load set to be applied to the structural model.

Format and Example(s):

LØAD = n

LØAD = 15

Option

Meaning

n Set identification of at least one external load card and hence must appear on at least one FØRCE, FØRCE1, FØRCE2, MØMENT, MØMENT1, MØMENT2, GRAV, PLØAD, PLØAD2, PLØAD3, RFØRCE, PRESAX, FØRCEAX, MØMAX, SLØAD, or LØAD card (Integer > 0).

- Remarks:
1. The above static load cards will not be used by NASTRAN unless selected in Case Control.
 2. A GRAV card cannot have the same set identification number as any of the other loading card types. If it is desired to apply a gravity load along with other static loads, a LØAD bulk data card must be used.
 3. LØAD is only applicable in statics, inertia relief, differential stiffness, buckling, and piecewise linear problems.
 4. The total load applied will be the sum of external (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement (SPC) Loads.
 5. Static, thermal and element deformation loads should have unique set identification numbers.

CASE CONTROL DECK

Case Control Data Card M2PP - Direct Input Mass Matrix Selection.

Description: Selects a direct input mass matrix.

Format and Example(s):

M2PP = name
M2PP = MDMIG
M2PP = M2PP

Option

Meaning

name	BCD name of a $[M_{pp}^{2d}]$ matrix that is input on the DMIG or DMIAX bulk data card.
------	---

Remarks: 1. M2PP is supported only in dynamics problems.
2. DMIG and DMIAX matrices will not be used unless selected.

NASTRAN DATA DECK

Case Control Data Card MAXLINES - Maximum Number of Output Lines.

Description: Sets the maximum number of output lines to a given value.

Format and Example(s):

MAXLINES = $\left\{ \frac{20000}{n} \right\}$

MAXLINES = 50000

Option

Meaning

n Maximum number of output lines which the user wishes to allow (Integer > 0).

Remarks:

1. Any time this number is exceeded, NASTRAN will terminate thru PEXIT.
2. This card may or may not override system operating control cards. Users should check with the local operations staff.

CASE CONTROL DECK

Case Control Data Card METHØD - Real Eigenvalue Extraction Method Selection.

Description: Selects the Real Eigenvalue Parameters to be used by the READ module.

Format and Example(s):

METHØD = n

METHØD = 33

<u>Option</u>	<u>Meaning</u>
n	Set identification number of an EIGR card (normal modes or modal formulation) or an EIGB card (buckling). (Integer > 0)

Remarks: An eigenvalue extraction method must be selected when extracting real eigenvalues using Functional Module READ.

NASTRAN DATA DECK

Case Control Data Card M0DES - Duplicate Case Control.

Description: Repeats case control M0DES times - to allow control of output in eigenvalue problems.

Format and Example(s):

M0DES = n
M0DES = 1

Option

Meaning

n Number of modes, starting with the first and proceeding sequentially upward, for which the case control or subcase control is to apply. (Integer > 0).

Remarks: 1. This card can be illustrated by an example. Suppose stress output is desired for the first five modes only and Displacements only thereafter. The following example would accomplish this:

```
SUBCASE 1
M0DES = 5
0UTPUT
STRESS = ALL
SUBCASE 6
0UTPUT
DISPLACEMENTS = ALL
BEGIN BULK
```

2. The M0DES card causes the results for each eigenvalue to be considered as a separate, successively numbered subcase, beginning with the subcase number containing the M0DES card.
3. If the M0DES card is not used, eigenvalue results are considered to be a part of a single subcase. Hence, any output requests for the single subcase will apply for all eigenvalues.
4. All eigenvectors with mode numbers greater than the number of records in Case Control are printed with the descriptors of the last Case Control record. For example, to suppress all printout for modes beyond the first three, the following Case Control deck could be used:

```
SUBCASE 1
M0DES = 3
DISPLACEMENTS = ALL
SUBCASE 4
DISPLACEMENTS = NONE
BEGIN BULK
```

CASE CONTROL DECK

Case Control Data Card MPC - Multipoint Constraint Set Selection.

Description: Selects the multipoint constraint set to be applied to the structural model.

Format and Example(s):

MPC = n

MPC = 17

Option

Meaning

n	"n" is the set identification of a Multipoint-Constraint Set and hence must appear on at least one MPC or MPCADD card. (Integer > 0).
---	---

Remarks: MPC or MPCADD cards will not be used by NASTRAN unless selected in Case Control.

NASTRAN DATA DECK

Case Control Data Card NLLØAD - Nonlinear Load Output Request.

Description: Requests form and type of nonlinear load output for Transient problems.

Format and Example(s):

$$\text{NLLØAD} \left[\left(\frac{\text{PRINT}}{\text{PUNCH}} \right) \right] = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NØNE} \end{Bmatrix}$$

NLLØAD = ALL

<u>Option</u>	<u>Meaning</u>
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Nonlinear loads for all solution points will be output.
NØNE	Nonlinear loads will not be output.
n	Set identification of previously appearing SET card. (Integer > 0). Only non-linear loads for points whose identification numbers appear on this SET card will be output.

- Remarks:
1. Both PRINT and PUNCH may be used.
 2. Nonlinear loads are output only in the solution (D or H) set.
 3. The output format will be SØRT2.
 4. An output request for ALL in Transient response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 5. THERMAL = NØNE allows overriding an overall output request.

CASE CONTROL DECK

Case Control Data Card NØNLINER - Nonlinear Load Set Selection.

Description: Selects nonlinear load for transient problems.

Format and Example(s):

NØNLINER = n

NØNLINER LOAD SET = 75

Option

Meaning

n Set identification of NØLINi cards (Integer > 0).

Remarks: NØLINi cards will not be used unless selected in Case Control.

NASTRAN DATA DECK

Case Control Data Card ØFREQUENCY - Output Frequency Set.

Description: Selects from the solution set of frequencies a subset for output requests. In flutter analysis, it selects a subset of velocities.

Format and Example(s):

$\text{ØFREQUENCY} = \left\{ \frac{\text{ALL}}{n} \right\}$

ØFREQUENCY = ALL

ØFREQUENCY SET = 15

Option

Meaning

ALL	Output for all frequencies will be printed out.
n	Set identification of previously appearing SET card. (Integer > 0). Output for frequencies closest to those given on this SET card will be output.

Remarks:

1. ØFREQUENCY is defaulted to ALL if it is not supplied.
2. In flutter analysis, the selected set lists velocities in input units. If there are n velocities in the list, the n points with velocities closest to those in the list will be selected for output.

CASE CONTROL DECK

Case Control Data Card ØLØAD - Applied Load Output Request

Description: Requests form and type of applied load vector output.

Format and Example(s):

$$\text{ØLØAD} \quad \left[\begin{array}{c} \text{SØRT1} \\ \text{SØRT2} \end{array}, \begin{array}{c} \text{PRINT} \\ \text{PUNCH} \end{array}, \begin{array}{c} \text{REAL} \\ \text{IMAG} \\ \text{PHASE} \end{array} \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NØNE} \end{array} \right\}$$

ØLØAD = ALL

ØLØAD(SØRT1, PHASE) = 5

<u>Option</u>	<u>Meaning</u>
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each grid point. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Complex Eigenvalue or Frequency Response problems.
ALL	Applied loads for all points will be output. (SØRT1 will only output nonzero values).
NØNE	Applied loads for no points will be output.
n	Set identification of previously appearing SET card. Only loads on points whose identification numbers appear on this SET card will be output (Integer > 0).

- Remarks:
- Both PRINT and PUNCH may be requested.
 - An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 - In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
 - A request for SØRT2 causes loads (zero and nonzero) to be output.
 - ØLØAD = NØNE allows overriding an overall output request.

NASTRAN DATA DECK

Case Control Data Card ØUTPUT - Output Packet Delimiter.

Description: Delimits the various output packets, structure plotter, curve plotter, and printer/punch.

Format and Example(s):

ØUTPUT $\left[\begin{array}{l} \text{PLØT} \\ \text{XYØUT} \\ \text{XYPLØT} \end{array} \right]$

ØUTPUT

ØUTPUT(PLØT)

ØUTPUT(XYØUT)

Option

Meaning

No qualifier

Beginning of printer output packet - this is not a required card.

PLØT

Beginning of structure plotter packet. This card must precede all structure plotter control cards.

XYØUT or
XYPLØT

Beginning of curve plotter packet. This card must precede all curve plotter control cards. XYPLØT and XYØUT are entirely equivalent.

Remarks:

1. The structure plotter packet and the curve plotter packet must be at the end of the Case Control Deck. Either may come first.
2. The delimiting of a printer packet is completely optional.

CASE CONTROL DECK

Case Control Data Card PLCØEFFICIENT - Piecewise Linear Coefficient Set.

Description: Selects the coefficient set for Piecewise Linear problems.

Format and Example(s):

$$\text{PLCØEFFICIENT} = \left\{ \begin{array}{c} \text{DEFAULT} \\ n \end{array} \right\}$$

PLCØEFFICIENT = DEFAULT

PLCØEFFICIENT = 25

Option

Meaning

DEFAULT A single default coefficient of value 1.0.

n Set identification of PLFACT card (Integer > 0).

Remarks: PLFACT cards will not be used unless selected.

NASTRAN DATA DECK

Case Control Data Card PLØTID - Plotter Identification.

Description: Defines BCD identification which will appear on the first frame of any NASTRAN plotter output.

Format and Example(s):

PLØTID = { Any BCD data }

PLØTID = MSC - BLDG. 125 BØX 91 - - RETURN TØ MACNEAL-SCHWENDLER CØRP.

- Remarks:
1. PLØTID must appear before the ØUTPUT(PLØT) or ØUTPUT(XYØUT) cards.
 2. The presence of PLØTID causes a special header frame to be plotted with the supplied identification plotted several times. This allows easy identification of NASTRAN plotter output.
 3. If no PLØTID card appears, no ID frame will be plotted.
 4. The PLØTID header frame will not be generated for the table plotters.

CASE CONTROL DECK

Case Control Data Card PRESSURE - Hydroelastic Pressure Output Request.

Description: Requests form and type of displacement and hydroelastic pressure vector output.

Format and Example(s):

$$\text{PRESSURE} \left[\begin{pmatrix} \text{SØRT1} & \text{PRINT} & \text{REAL} \\ \text{SØRT2} & \text{PUNCH} & \text{IMAG} \\ & & \text{PHASE} \end{pmatrix} \right] = \left\{ \begin{matrix} \text{ALL} \\ n \\ \text{NØNE} \end{matrix} \right\}$$

PRESSURE = 5

PRESSURE(IMAG) = ALL

PRESSURE(SØRT2, PUNCH, REAL) = ALL

Option

Meaning

SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ \leq \text{phase} < 360.0^\circ$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements and pressures for all points will be output.
NØNE	Displacements and pressures for no points will be output.
n	Set identification of previously appearing SET card. Only displacements and pressures of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks: 1. Both PRINT and PUNCH may be requested.

2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
4. DISPLACEMENT and VECTØR are alternate forms and are entirely equivalent to PRESSURE.
5. PRESSURE = NØNE allows overriding an overall output request.

CASE CONTROL DECK

Case Control Data Card RANDØM - Random Analysis Set Selection

Description: Selects the RANDPS and RANDTi cards to be used in Random Analysis.

Format and Example(s):

RANDØM = n

RANDØM = 177

Option

Meaning

<u>Option</u>	<u>Meaning</u>
n	Set identification of RANDPS and RANDTi cards to be used in RANDØM analysis (Integer > 0).

Remarks:

1. RANDPS cards must be selected to do Random Analysis.
2. RANDPS must be selected in the first subcase of the current loop. RANDPS may not reference subcases in a different loop.

NASTRAN DATA DECK

Case Control Data Card REPCASE - Repeat Case Subcase Delimiter.

Description: Delimits and identifies a repeated subcase.

Format and Example(s):

REPCASE n
REPCASE 137

<u>Option</u>	<u>Meaning</u>
n	Subcase number (Integer > 1).

Remarks:

1. "n" must be strictly increasing (i.e. greater than all previous subcase set identification numbers).
2. This case will only re-output the previous real case. This allows additional set specification.
3. REPCASE may only be used in Statics or Inertia Relief.
4. One or more repeated subcases (REPCASEs) must immediately follow the subcase (SUBCASE) to which they refer. (See example 4 in Section 2.3.3).

CASE CONTROL DECK

Case Control Data Card SACCELERATION - Solution Set Acceleration Output Request

Description: Requests form and type of solution set acceleration output.

Format and Example(s):

$$\text{SACCELERATION} \left[\begin{array}{c} \text{SORT1} \\ \text{SORT2} \end{array}, \begin{array}{c} \text{PRINT} \\ \text{PUNCH} \end{array}, \begin{array}{c} \text{REAL} \\ \text{IMAG} \\ \text{PHASE} \end{array} \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NONE} \end{array} \right\}$$

SACCELERATION = ALL

SACCELERATION(PUNCH, IMAG) = 142

Option

Meaning

SORT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SORT1 is not available in Transient problems (where the default is SORT2).
SORT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SORT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Frequency Response problems.
ALL	Acceleration for all solution points (modes) will be output.
NONE	Acceleration for no solution points (modes) will be output.
n	Set identification of a previously appearing SET card. Only accelerations of points whose identification numbers appear on this SET card will be output (Integer > 0)

- Remarks:
- Both PRINT and PUNCH may be requested.
 - An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 - Acceleration output is only available for Transient and Frequency Response problems.
 - In a Frequency Response problem any request for SORT2 output causes all output to be SORT2.
 - SACCELERATION = NONE allows overriding an overall output request.

NASTRAN DATA DECK

Case Control Data Card SDAMPING - Structural Damping.

Description: Selects table which defines damping as a function of frequency in Modal Formulation problems.

Format and Example(s):

SDAMPING = n
SDAMPING = 77

Option

Meaning

n Set identification of a TABDMP1 table (Integer > 0).

Remarks: If SDAMPING is not used BHH = [0].

CASE CONTROL DECK

Case Control Data Card SDISPLACEMENT - Solution Set Displacement Output Request.

Description: Requests form and type of solution set displacement output.

Format and Example(s):

$$\text{SDISPLACEMENT} \left[\begin{pmatrix} \text{SØRT1} & \text{PRINT} & \text{REAL} \\ \text{SØRT2} & \text{PUNCH} & \text{IMAG} \\ & & \text{PHASE} \end{pmatrix} \right] = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NØNE} \end{Bmatrix}$$

SDISPLACEMENT = ALL

SDISPLACEMENT(SØRT2, PUNCH, PHASE) = NØNE

Option

Meaning

SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).	1
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.	
PRINT	The printer will be the output media.	
PUNCH	The card punch will be the output media.	
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.	
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Complex Eigenvalue or Frequency Response problems.	
ALL	Displacements for all points (modes) will be output.	
NØNE	Displacements for no points (modes) will be output.	
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).	

Remarks: 1. Both PRINT and PUNCH may be requested.

2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
4. SVECTØR is an alternate form which is entirely equivalent to SDISPLACEMENT.
5. SDISPLACEMENT = NØNE allows overriding an overall output request.

NASTRAN DATA DECK

Case Control Data Card SET - Set Definition Card.

Description: 1) Lists identification numbers (point or element) for output requests.
2) Lists the frequencies for which output will be printed in Frequency Response Problems.

Format and Example(s):

1) SET n = {i₁ [, i₂, i₃ THRU i₄ EXCEPT i₅, i₆, i₇, i₈ THRU i₉]}

SET 77 = 5

SET 88 = 5, 6, 7, 8, 9, 10 THRU 55 EXCEPT 15, 16, 77,
78, 79, 100 THRU 300

SET 99 = 1 THRU 100000

2) SET n = {r₁ [, r₂, r₃, r₄]}

SET 101 = 1.0, 2.0, 3.0

SET 105 = 1.009, 10.2, 13.4,
14.0, 15.0

Option

Meaning

n	Set identification (Integer > 0). Any set may be redefined by reassigning its identification number. Sets inside SUBCASE delimiters are local to the SUBCASE.
i ₁ , i ₂ etc.	Element or point identification number at which output is requested. (Integer > 0) If no such identification number exists, the request is ignored.
i ₃ THRU i ₄	Output at set identification numbers i ₃ thru i ₄ (i ₄ > i ₃).
EXCEPT	Set identification numbers following EXCEPT will be deleted from output list as long as they are in the range of the set defined by the immediately preceding THRU.
r ₁ , r ₂ etc.	Frequencies for output (Real > 0.0). The nearest solution frequency will be output. EXCEPT and THRU cannot be used.

Remarks:

1. A SET card may be more than one physical card. A comma (,) at the end of a physical card signifies a continuation card. Commas may not end a set.
2. Set identification numbers following EXCEPT within the range of the THRU must be in ascending order.

CASE CONTROL DECK

Case Control Data Card SPC - Single-Point Constraint Set Selection.

Description : Selects the single-point constraint set to be applied to the structural model.

Format and Example(s):

SPC = n

SPC = 10

Option

Meaning

n	Set identification of a single-point constraint set and hence must appear on a SPC, SPC1 or SPCADD card (Integer > 0).
---	--

Remarks: SPC, SPC1 or SPCADD cards will not be used by NASTRAN unless selected in Case Control.

NASTRAN DATA DECK

Case Control Data Card SPCFORCES - Single-Point Forces of Constraint Output Request.

Description: Requests form and type of Single-Point Force of constraint vector output.

Format and Example(s):

$$\text{SPCFORCES} \left[\begin{array}{c} \text{SØRT1} \\ \text{SØRT2} \end{array}, \begin{array}{c} \text{PRINT} \\ \text{PUNCH} \end{array}, \begin{array}{c} \text{REAL} \\ \text{IMAG} \\ \text{PHASE} \end{array} \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NONE} \end{array} \right\}$$

SPCFORCES = 5

SPCFORCES(SØRT2, PUNCH, PRINT, IMAG) = ALL

SPCFORCES(PHASE) = NONE

<u>Option</u>	<u>Meaning</u>
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each grid point. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° < phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Single-Point forces of constraint for all points will be output. (SØRT1 will only output nonzero values.)
NONE	Single point forces of constraint for no points will be output.
n	Set identification of previously appearing SET card. Only single-point forces constraint for points whose identification numbers appear on this SET card will be output (Integer > 0).

- Remarks:
- Both PRINT and PUNCH may be requested.
 - An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 - In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
 - A request for SØRT2 causes loads (zero and nonzero) to be output.
 - SPCFORCES = NONE allows overriding an overall output request.

CASE CONTROL DECK

Case Control Data Card STRESS - Element Stress Output Request.

Description: Requests form and type of element stress output.

Format and Example(s):

$$\text{STRESS} \left[\begin{array}{c} \text{SØRT1} \\ \text{SØRT2} \end{array}, \begin{array}{c} \text{PRINT} \\ \text{PUNCH} \end{array}, \begin{array}{c} \text{REAL} \\ \text{IMAG} \\ \text{PHASE} \end{array} \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NONE} \end{array} \right\}$$

STRESS = 5

STRESS = ALL

STRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

Option

Meaning

SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stresses for no points will be output.

Remarks: 1. Both PRINT and PUNCH may be requested.

2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. ELSTRESS is an alternate form and is entirely equivalent to STRESS.
5. STRESS = NØNE allows overriding an overall output request.

NASTRAN DATA DECK

Case Control Data Card SUBCASE - Subcase Delimiter.

Description: Delimits and identifies a subcase.

Format and Example(s):

SUBCASE n
SUBCASE 101

Option

Meaning

n Subcase identification number (Integer > 0).

- Remarks:
1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
 2. Plot requests and RANDØM requests refer to n.

CASE CONTROL DECK

Case Control Data Card SUBCØM - Combination Subcase Delimiter.

Description: Delimits and identifies a combination subcase.

Format and Example(s):

SUBCØM n
SUBCØM 125

Option

Meaning

n Subcase identification number (Integer > 2).

- Remarks:
1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
 2. A SUBSEQ card must appear in this subcase.
 3. SUBCØM may only be used in Statics or Inertia Relief problems.
 4. Output requests above the subcase level will be utilized.

NASTRAN DATA DECK

Case Control Data Card SUBSEQ - Subcase Sequence Coefficients.

Description: Gives the coefficients for forming a linear combination of the previous subcases.

Format and Example(s):

SUBSEQ = R_1 [, R_2 , R_3 , . . . , R_N]

SUBSEQ = 1.0, -1.0, 0.0, 2.0

Option

Meaning

R_1 to R_N Coefficients of the previously occurring subcases (Real).

Remarks: 1. A SUBSEQ card must only appear in a SUBCØM subcase.

2. A SUBSEQ card may be more than one physical card. A comma at the end signifies a continuation card.

3. SUBSEQ may only be used in Statics or Inertia Relief problems.

CASE CONTROL DECK

Case Control Data Card SUBTITLE - Output Subtitle.

Description: Defines a BCD subtitle which will appear on the second heading line of each page of NASTRAN printer output.

Format and Example(s):

SUBTITLE = { Any BCD data }

SUBTITLE = NASTRAN PROBLEM NO. 5-1A

- Remarks:
1. SUBTITLE appearing at the subcase level will title output for that subcase only.
 2. SUBTITLE appearing before all subcases will title any outputs which are not subcase dependent.
 3. If no SUBTITLE card is supplied, the subtitle line will be blank.
 4. SUBTITLE information is also placed on NASTRAN plotter output as applicable.

NASTRAN DATA DECK

Case Control Data Card SVECTØR - Solution Set Displacement Output Request.

Description: Requests form and type of solution set displacement output.

Format and Example(s):

$$\text{SVECTØR} \left[\left(\begin{array}{c} \text{SØRT1} \\ \text{SØRT2} \end{array}, \begin{array}{c} \text{PRINT} \\ \text{PUNCH} \end{array}, \begin{array}{c} \text{REAL} \\ \text{IMAG} \\ \text{PHASE} \end{array} \right) \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NØNE} \end{array} \right\}$$

SVECTØR = ALL

SVECTØR(SØRT2, PUNCH, PHASE) = NØNE

Option

Meaning

SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points (modes) will be output.
NØNE	Displacements for no points (modes) will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks: 1. Both PRINT and PUNCH may be requested.

2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In a frequency response problem any request for SØRT2 causes all output to be SØRT2.
4. SDISPLACEMENT is an alternate form and is entirely equivalent to SVECTØR.
5. SVECTØR = NØNE allows overriding an overall output request.

CASE CONTROL DECK

Case Control Data Card SVELØCITY - Solution Set Velocity Output Request

Description: Requests form and type of solution set velocity output.

Format and Example(s):

$$\text{SVELØCITY} \left[\begin{array}{c} \text{SØRT1} \quad \text{PRINT} \quad \text{REAL} \\ \text{SØRT2} \quad \text{PUNCH} \quad \text{IMAG} \\ \text{PHASE} \end{array} \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NONE} \end{array} \right\}$$

SVELØCITY = 5

SVELØCITY(SØRT2, PUNCH, PRINT, PHASE) = ALL

<u>Option</u>	<u>Meaning</u>
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Frequency Response problems.
ALL	Velocity for all solution points (modes) will be output.
NØNE	Velocity for no solution points (modes) will be output.
n	Set identification of a previously appearing SET card. Only velocities of points whose identification numbers appear on this SET card will be output (Integer > 0).

- Remarks:
- Both PRINT and PUNCH may be requested.
 - An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
 - Velocity output is only available for Transient and Frequency Response problems.
 - In a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
 - SVELØCITY = NØNE allows overriding an overall output request.

NASTRAN DATA DECK

Case Control Data Card SYM - Symmetry Subcase Delimiter.

Description: Delimits and identifies a symmetry subcase.

Format and Example(s):

SYM n
SYM 123

Option

Meaning

n Subcase identification number (Integer > 0).

- Remarks:
1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
 2. Plot requests and RANDOM requests should refer to n.
 3. Overall output requests will not propagate into a SYM subcase (i.e. any output desired must be requested within the subcase).
 4. SYM may only be used in Statics or Inertia Relief.

CASE CONTROL DECK

Case Control Data Card SYMCØM - Symmetry Combination Subcase Delimiter.

Description: Delimits and identifies a symmetry combination subcase.

Format and Example(s):

SYMCØM n
SYMCØM 123

Option

Meaning

n Subcase identification number (Integer > 2).

- Remarks:
1. The subcase identification number, n, must be strictly increasing (i.e., greater than all previous subcase identification numbers).
 2. SYMCØM may only be used in Statics or Inertia Relief problems.

NASTRAN DATA DECK

Case Control Data Card SYMSEQ - Symmetry Sequence Coefficients.

Description: Gives the coefficients for combining the symmetry subcases into the total structure.

Format and Example(s):

SYMSEQ = R_1 , R_2 , R_3 --- R_n

SYMSEQ = 1.0, -2.0, 3.0, 4.0

Option

Meaning

R_1 to R_N Coefficients of the previously occurring N SYM subcases (Real).

- Remarks:
1. A SYMSEQ card may only appear in a SYMCØM subcase.
 2. The default value for the coefficients is 1.0 if no SYMSEQ card appears.
 3. A SYMSEQ card may consist of more than one physical card.
 4. SYMSEQ may only be used in Statics or Inertia Relief.

CASE CONTROL DECK

Case Control Data Card TEMPERATURE - Thermal Properties Set Selection.

Description: Selects the temperature set to be used in either material property calculation or thermal loading.

Format and Example(s):

TEMPERATURE $\left[\begin{array}{c} \text{MATERIAL} \\ \text{LOAD} \\ \text{BOTH} \end{array} \right] = n$

TEMPERATURE(LØAD) = 15

TEMPERATURE(MATERIAL) = 7

TEMPERATURE = 7

<u>Option</u>	<u>Meaning</u>
MATERIAL	The selected temperature table will be used to determine temperature-dependent material properties indicated on the MATii type cards.
LØAD	The selected temperature table will be used to determine an equivalent static load.
BØTH	Both options, MATERIAL and LØAD will use the same temperature table.
n	Set identification number of TEMP, TEMPD, TEMPP1, TEMPP2, TEMPP3, TEMPRB, or TEMPAX cards (Integer > 0).

- Remarks:
1. Only one temperature-dependent material request may be made in any problem and must be above the subcase level.
 2. Thermal loading may only be used in Statics, Inertia Relief, Differential Stiffness, and Buckling problems.
 3. Temperature-dependent materials may not be used in Piecewise Linear problems.
 4. The total load applied will be the sum of external (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement (SPC) loads.
 5. Static, thermal and element deformation loads should have unique set identification numbers.

NASTRAN DATA DECK

Case Control Data Card TFL - Transfer Function Set Selection.

Description: Selects the Transfer function set to be added to the direct input matrices.

Format and Example(s):

TFL = n

TFL = 77

Option

Meaning

n Set identification of a TF card (Integer > 0).

Remarks:

1. Transfer functions will not be used unless selected in the Case Control Deck.
2. Transfer functions are supported on dynamics problems only.
3. Transfer functions are simply another form of direct matrix input.

CASE CONTROL DECK

Case Control Data Card THERMAL - Temperature Output Request.

Description: Requests form and type of temperature vector output.

Format and Example(s):

$$\text{THERMAL} \left[\begin{pmatrix} \text{PRINT} \\ \text{PUNCH} \end{pmatrix} \right] = \left\{ \begin{matrix} \text{ALL} \\ n \\ \text{NONE} \end{matrix} \right\}$$

THERMAL = 5

THER(PRINT,PUNCH) = ALL

Option

Meaning

PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Temperatures for all points will be output.
NONE	Temperatures for no points will be output.
n	Set identification of previously appearing SET card. Only temperatures of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. THERMAL output request is designed for use with the Heat Transfer option. The printed output will have temperature headings and the punched output will be TEMP bulk data cards. The SID on a bulk data card will be the subcase number (= 1 if no defined subcases). The output format will be SØRT1 for Static problems and SØRT2 for Transient problems.
3. An output request for ALL in Transient response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
4. DISPLACEMENT and VECTOR are alternate forms and are entirely equivalent to THERMAL.
5. THERMAL = NONE allows overriding an overall output request.

CASE CONTROL DECK

Case Control Data Card TITLE - Output Title.

Description: Defines a BCD title which will appear on the first heading line of each page of NASTRAN printer output.

Format and Example(s):

TITLE = { Any BCD data }

TITLE = **\$// ABCDEFGHI \$

- Remarks:
1. TITLE appearing at the subcase level will title output for that subcase only.
 2. TITLE appearing before all subcases will title any outputs which are not subcase dependent.
 3. If no TITLE card is supplied, the title line will contain data and page numbers only.
 4. TITLE information is also placed on NASTRAN plotter output as applicable.

NASTRAN DATA DECK

Case Control Data Card TSTEP - Transient Time Step Set Selection.

Description: Selects integration and output time steps for Transient problems.

Format and Example(s):

TSTEP = n

TSTEP = 731

Option

Meaning

n	Set identification of a selected TSTEP bulk data card (Integer > 0).
---	--

Remarks: 1. A TSTEP card must be selected to execute a Transient problem.

2. Only one TSTEP card may have this value of n.

CASE CONTROL DECK

Case Control Data Card VECTØR - Displacement Output Request.

Description: Requests form and type of displacement vector output.

Format and Example(s):

$$\text{VECTØR} \left[\left(\begin{array}{c} \text{SØRT1} \\ \text{SØRT2} \end{array}, \begin{array}{c} \text{PRINT} \\ \text{PUNCH} \end{array}, \begin{array}{c} \text{REAL} \\ \text{IMAG} \\ \text{PHASE} \end{array} \right) \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NØNE} \end{array} \right\}$$

VECTØR = 5

VECTØR(REAL) = ALL

VECTØR(SØRT2, PUNCH, REAL) = ALL

Option

Meaning

SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available on Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ \leq \text{phase} < 360.0^\circ$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points will be output.
NØNE	Displacements for no points will be output.
n	Set identification of a previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

- Remarks:
- Both PRINT and PUNCH may be requested.
 - On a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
 - DISPLACEMENT and PRESSURE are alternate forms and are entirely equivalent to VECTØR.
 - VECTØR = NØNE allows overriding an overall output request.

NASTRAN DATA DECK

Case Control Data Card VELØCITY - Velocity Output Request.

Description: Requests form and type of velocity vector output.

Format and Example(s):

$$\text{VELØCITY} \left[\left(\begin{array}{c} \text{SØRT1} \\ \text{SØRT2} \end{array}, \begin{array}{c} \text{PRINT} \\ \text{PUNCH} \end{array}, \begin{array}{c} \text{REAL} \\ \text{IMAG} \\ \text{PHASE} \end{array} \right) \right] = \left\{ \begin{array}{c} \text{ALL} \\ n \\ \text{NØNE} \end{array} \right\}$$

VELØCITY = 5

VELØCITY(SØRT2, PHASE, PUNCH) = ALL

<u>Option</u>	<u>Meaning</u>
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0^\circ < \text{phase} < 360.0^\circ$) on Frequency Response problems.
ALL	Velocity for all solution points will be ouput.
NØNE	Velocity for no solution points will be output.
n	Set identification of a previously appearing SET card. Only velocities of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks: 1. Both PRINT and PUNCH may be requested.

- An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
- Velocity output is only available for Transient and Frequency Response problems.
- In a Frequency Response problem any request for SØRT2 output causes all output to be SØRT2.
- VELØCITY = NØNE allows overriding an overall output request.

CASE CONTROL DECK

Case Control Data Card \$ - Comment Card.

Description: Defines a comment card by specifying a \$ in column one with commentary text appearing in columns 2-80.

Format and Example(s):

\$ {Any BCD data}

\$---THIS IS AN EXAMPLE OF A COMMENT CARD.

Remarks: Unlike other Case Control cards which are free field, the comment card must have the \$ in column 1.

NASTRAN DATA DECK

2.4 BULK DATA DECK

The primary NASTRAN input medium is the Bulk Data card. These cards are used to define the structural model and various pools of data which may be selected by Case Control at execution time.

For large problems the Bulk Data Deck may consist of several thousand cards. In order to minimize the handling of large numbers of cards, provision has been made in NASTRAN to store the bulk data on the Problem Tape, from which it may be modified on subsequent runs. A User's Master File (Section 2.5) is also provided for the storage of Bulk Data Decks.

For any cold start, the entire Bulk Data Deck must be submitted. Thereafter, if the original run was checkpointed, the Bulk Data Deck exists on the Problem Tape in sorted form where it may be modified and reused on restart. On restart the bulk data cards contained in the Bulk Data Deck are added to the bulk data contained on the Old Problem Tape. Cards are removed from the Old Problem Tape (or the User's Master File) by the use of a delete card. Cards to be deleted are indicated by inserting a bulk data card with a / in column one and the sorted bulk data sequence numbers in fields two and three. All bulk data cards in the range of the sequence numbers in fields two and three will be deleted. In the case where only a single card is deleted, field three may be left blank.

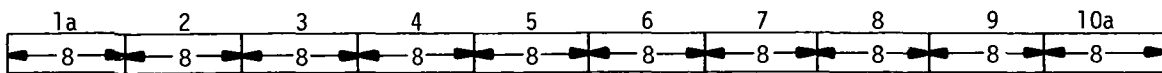
The Bulk Data Deck may be submitted with the cards in any order as a sort is performed prior to the execution of the Input File Processor. It should be noted that the machine time to perform this is minimized for a deck that is already sorted. The sort time for a badly sorted deck will become significant for large decks. The user may obtain a printed copy of either the unsorted or sorted bulk data by selection in the Case Control Deck. A sorted echo is necessary in order to make modifications on a secondary execution using the Problem Tape. This echo is automatically provided unless specifically suppressed by the user.

2.4.1 Format of Bulk Data Cards

The bulk data card format is variable to the extent that any quantity except the mnemonic can be punched anywhere within a specified 8 or 16-column field. The normal card uses an 8-column field as indicated in the following diagram:

NASTRAN DATA DECK

Small Field Bulk Data Card



The mnemonic is punched in field 1 beginning in column 1. Fields 2-9 are for data items. The only limitations in data items are that they must lie completely within the designated field, have no imbedded blanks, and must be of the proper type, i.e., blank, integer, real, double precision, or BCD*. All real numbers, including zero, must contain a decimal point. A blank will be interpreted as a real zero or integer zero as required. Real numbers may be encoded in various ways. For example, the real number 7.0 may be encoded as 7.0, .7E1, 0.7+1, 70.-1, .70+1, etc. A double precision number must contain both a decimal point and an exponent with the character D such as 7.0D0. Double precision data values are only allowed in a few situations, such as on the PARAM card. BCD data values consist of one to eight alphanumeric characters, the first of which must be alphabetic.

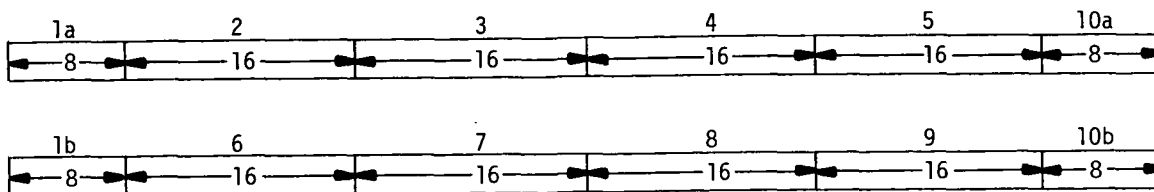
Normally field 10 is reserved for optional user identification. However, in the case of continuation cards field 10 (except column 73 which is not referenced) is used in conjunction with field 1 of the continuation card as an identifier and hence must contain a unique entry. The continuation card contains the symbol + in column 1 followed by the same seven characters that appeared in columns 74-80 of field 10 of the card that is being continued. This allows the data to be submitted as an unsorted deck.

The small field data card should be more than adequate for the kinds of data normally associated with structural engineering problems. Since abbreviated forms of floating point numbers are allowed, up to seven significant decimal digits may be used in an eight-character field. Occasionally, however, the input is generated by another computer program or is available in a form where a wider field would be desirable. For this case, the larger field format with a 16-character data field is provided. Each logical card consists of two physical cards as indicated in the following diagram:

*See SEQGP and SEQEP for exceptions.

BULK DATA DECK

Large Field Bulk Data Card



The large field card is denoted by placing the symbol * after the mnemonic in field 1a and some unique character configuration in the last 7 columns of field 10a. The second physical card contains the symbol * in column 1 followed by the same seven characters that appeared after column 73 in field 10a of the first card. The second card may in turn be used to point to a large or small field continuation card, depending on whether the continuation card contains the symbol * or the symbol + in column 1. The use of multiple and large field cards are illustrated in the following examples:

Small Field Card with Small Field Continuation Card.

TYPE									QED123
+ED123									

Large Field Card

TYPE*									QED124
*ED124									

Large Field Card with Large Field Continuation Card

TYPE*									QED301
*ED301									QED302
*ED302									QED305
*ED305									

Large Field Card Followed by a Small Field Continuation Card and a Large Field Continuation Card

TYPE*									QED462
*ED462									QED421
+ED421									QED361
*ED361									QED291
*ED291									


NASTRAN DATA DECK

Small Field Card with Large Field Continuation Card

TYPE									QED632
*ED632									QED204
*ED204									

In the above examples column 73 arbitrarily contains the symbol Q in all cases where field 10 is used as a pointer. However, column 73 could have been left blank or the same symbol used in column 1 of the following card could have been used (i.e., the symbols * or +).

2.4.2 Bulk Data Card Descriptions

The detailed descriptions of the bulk data cards are contained in this section in alphabetical order. For details pertaining to the use of each card and for a discussion of the cards in functional groups, the user is referred to Section 1 - Structural Modeling. Small field examples are given for each card along with a description of the contents of each field. In the Format and Example section of each card description, both a symbolic card format description and an example of an actual card are shown. Literal constants are shown in the card format section enclosed in quotes (e.g., "0"). Fields that are required to be blank are indicated in the card format section by  whenever they are followed by nonblank fields or whenever such notation will clarify the card description.

The Input File Processor will produce error messages for any cards that do not have the proper format or which contain illegal data.

Continuation cards need not be present unless they contain required data. In the case of multiple continuation cards, the intermediate cards must be present (even though fields 2-9 are blank) if one of the following cards contains data in fields 2-9. In addition, a double field format requires at least two cards (or subsequent multiples of two) so that 10 data fields are included. Thus one or more double field cards may contain no data.

BULK DATA DECK

Input Data Card \$ Comment

Description: For user convenience in inserting commentary material into the unsorted echo of his input Bulk Data Deck. The \$ card is otherwise ignored by the program. These cards will not appear in a sorted echo nor will they exist on the New Problem Tape.

Format and Example:

1	2	3	4	5	6	7	8	9	10
\$	followed	by any	legitimate	characters	in card	columns	2-80		
\$	THIS IS	A REMARK	(*, '\$\$)-	/					

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card / Delete

Description: Delete cards are used to remove cards from either the Old Problem Tape on restart or the User's Master File.

Format and Example:

1	2	3	4	5	6	7	8	9	10
/	K1	K2							
/	4								

Field

Contents

K1 Sorted sequence number of first card in sequence to be removed
 K2 Sorted sequence number of last card in sequence to be removed

Remarks:

1. The delete card causes bulk data cards having sort sequence numbers K1 thru K2 to be removed from the Bulk Data Deck.
2. If K2 is blank, only card K1 is removed from the Bulk Data Deck.
3. If neither an Old Problem Tape nor a User's Master File are used in the current execution, the delete cards are ignored.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card ADUMi Dummy Element Attributes

Description: Defines attributes of the dummy elements ($1 \leq i \leq 9$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
ADUMi	NG	NC	NP	ND					
ADUM2	8	2	1	3					

Field

NG Number of grid points connected by DUMi dummy element (Integer > 0)

NC Number of additional entries on CDUMi connection card (Integer ≥ 0)

NP Number of additional entries on PDUMi property card (Integer ≥ 0)

ND Number of displacement components at each grid point used in generation of differential stiffness matrix (Integer 3 or 6)

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card AEFACT Aerodynamic Spanwise Divisions

Description: Used to specify box division points for flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AEFACT	SID	D1	D2	D3	D4	D5	D6	D7	ABC
AEFACT	97	.3	.7	1.0					
+BC	D8	D9	--etc.--						

Field

Contents

SID Set identification number (unique Integer > 0).

Di Division point (Real).

Remarks:

1. These factors must be selected by a CAERO data card to be used by NASTRAN.
2. Imbedded blank fields are forbidden.
3. There is one more division point than the number of boxes.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card AERØ Aerodynamic Physical Data

Description: Gives basic aerodynamic parameters.

Format and Examples:

1	2	3	4	5	6	7	8	9	10
AERØ	ACSID	VSØUND	REFC	RHØREF	SYMxz	SYMxy			
AERØ	3	1.3+4	100.	1.-5		1			

Field

Contents

ACSID	Aerodynamic coordinate system identification (Integer ≥ 0). See Remark 2.
VSØUND	Speed of sound (Real).
REFC	Reference length (for reduced frequency) (Real).
RHØREF	Reference density (Real).
SYMxz	Symmetry key for aero coordinate X-Z plane (Integer) (+1 for sym, =0 for no sym, -1 for anti-sym).
SYMxy	Symmetry key for aero coordinate X-Y plane can be used to simulate ground effects (Integer), same code as SYMxz.

Remarks:

1. This card is required for aerodynamic problems. Only one AERØ card is allowed.
2. The ACSID must be a rectangular coordinate system. Flow is in the positive x direction.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card ASET Selected Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to place in the analysis set. Used to define the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ASET	ID	C	ID	C	ID	C	ID	C	
ASET	16	2	23	3516			1	4	

<u>Field</u>	<u>Contents</u>
ID	Grid or scalar point identification number (Integer > 0)
C	Component number, zero or blank for scalar points, any unique combination of the digits 1-6 for grid points

- Remarks:
- Coordinates specified on ASET cards may not be specified on ØMIT, ØMIT1, ASET1, SUPØRT, SPC or SPC1 cards nor may they appear as dependent coordinates in multipoint constraint relations (MPC) or as permanent single-point constraints on a GRID card.
 - As many as 24 coordinates may be placed in the analysis set by a single card.
 - When ASET and/or ASET1 cards are present, all degrees of freedom not otherwise constrained will be placed in the Ø-set.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card ASET1 Selected Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to place in the analysis set. Used to define the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ASET1	C	G	G	G	G	G	G	G	abc
ASET1	345	2	1	3	10	9	6	5	ABC
+bc	G	G	G	-etc.-					
+BC	7	8							

Alternate Form

-etc.-

ASET1	C	ID1	"THRU"	ID2					
ASET1	123456	7	THRU	109					

Field

Contents

C Component number (any unique combination of the digits 1-6 [with no imbedded blanks] when point identification numbers are grid points; must be null or zero if point identification numbers are scalar points).

G, ID1, ID2 Grid or scalar point identification numbers (Integer > 0, ID1 < ID2)

- Remarks:
1. A coordinate referenced on this card may not appear as a dependent coordinate in a multi-point constraint relation (MPC card), nor may it be referenced on an SPC, SPC1, OMIT, OMIT1, ASET, or SUPORT card or on a GRID card as permanent single-point constraints.
 2. When ASET and/or ASET1 cards are present, all degrees of freedom not otherwise constrained will be placed in the 0-set.
 3. If the alternate form is used, all of the grid (or scalar) points ID1 thru ID2 are assumed.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card AXIC

Axisymmetric Problem "Flag"

Description: Defines the existence of a model containing CCONEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AXIC	H								
AXIC	15								

Field	Contents
-------	----------

H	Highest harmonic defined for the problem ($0 \leq \text{Integer} \leq 998$)
---	---

Remarks: 1. Only one (1) AXIC card is allowed. When the AXIC card is present, most other cards are not allowed. The types which are allowed with the AXIC card are listed below.

CCONEAX	GRAV	RLØAD1
CTRAPAX	LØAD	RLØAD2
CTRIAAX	MAT1	SECTAX
DAREA	MATT1	SPCADD
DELAY	MØMAX	SPCAX
DLØAD	MØMENT	SUPAX
DMI	MPCADD	TABDMP1
DMIG	MPCAX	TABLED1
DPHASE	NØLIN1	TABLED2
DSFACT	NØLIN2	TABLED3
EIGB	NØLIN3	TABLED4
EIGC	NØLIN4	TABLEM1
EIGP	ØMITAX	TABLEM2
EIGR	PARAM	TABLEM3
EPØINT	PCONEAX	TABLEM4
FØRCE	PØINTAX	TEMPAX
FØRCEAX	PRESAX	TF
FREQ	PTRAPAX	TIC
FREQ1	PTRIAAX	TLØAD1
FREQ2	RINGAX	TLØAD2
		TSTEP

2. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
3. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card AXIF

Fluid Related Axisymmetric Parameters

Description: Defines basic parameters and the existence of an axisymmetric fluid analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AXIF	CID	G	DRHØ	DB	NØSYM	F			abc
AXIF	2	32.2	0.12	2.5+5	YES				CARD-1
+bc	N1	N2	N3	N4	N5	N6	N7	N8	def
+ARD-1	1	2	3		4		7	10	

-etc.-

Alternate form of continuation card:

+bc	N1	"THRU"	Ni						def
+ARD-1	0	THRU	10						

-etc.-

Alternate form of continuation card:

+bc	N1	"THRU"	Ni	"STEP"	NS				def
+ARD-1	0	THRU	9	STEP	3				

-etc.-

Field

Contents

CID	Fluid Coordinate System identification number (Integer > 0)
G	Value of gravity for fluid elements in axial direction (Real)
DRHØ	Default mass density for fluid elements (Real > 0.0 or blank)
DB	Default bulk modulus for fluid elements (Real)
NØSYM	Request for nonsymmetric (sine) terms of series (BCD: "YES" or "NO")
F	Flag specifying harmonics (Blank - harmonic specified, or BCD - "NØNE")
Nn	Harmonic numbers for solution, an increasing sequence of integers. On the standard continuation card blanks are ignored. On the alternate form continuation cards, "THRU" implies all numbers including upper and lower integer (Blank, or integer, $0 \leq Nn < 100$, or BCD: "THRU" or "STEP")
NS	Every NSth step of the harmonic numbers specified in the "THRU" range is used for solution (Integer if field 5 is "STEP", $Ni = I \cdot NS + N1$ where I is an integer)

Remarks: 1. Only one (1) AXIF card is allowed.

2. CID must reference a cylindrical or spherical coordinate system.

3. Positive gravity (+G) implies that the direction of free fall is in the -Z direction of the Fluid Coordinate System.

4. The DRHØ value replaces blank values of RHØ on the FSLIST, BDYLIST and CFLUIDi cards.

5. The DB value replaces blank values of B on the CFLUIDi cards. If the CFLUIDi entry is blank and DB is zero or blank, the fluid is incompressible.

6. If NØSYM=YES, both sine and cosine terms are specified. If NØSYM=NØ, only cosine terms are specified.

(Continued)

NASTRAN DATA DECK

AXIF (cont.)

7. If F = NONE, no harmonics are specified, no fluid elements are necessary, and no continuation cards may be present.

Example:

1	2	3	4	5	6	7	8	9	10
AXIF	100	-386.0		0.0	NØ				+1
+1	0	THRU	50	STEP	5				+2
+2	52								+3
+3	54	THRU	57						+4
+4	61	THRU	65						+5
+5	68		71		72	75			+6
+6	81	92							END

BULK DATA DECK

Input Data Card AXSLØT Axisymmetric slot analysis parameter

Description: Defines the harmonic index and the default values for acoustic analysis cards.

Format and Example:

11	2	3	4	5	6	7	8	9	10
AXSLØT	RHØD	BD	N	WD	MD				
AXSLØT	0.003	1.5+2	3	0.75	6				

Field

Contents

RHØD	Default density of fluid-mass/volume (Real \neq 0.0 or blank)
BD	Default bulk modulus of fluid = (force/volume ratio change) (Real \geq 0.0 or blank)
N	Harmonic index number (Integer \geq 0)
WD	Default slot width (Real \geq 0.0 or blank)
MD	Default number of slots (Integer \geq 0 or blank)

- Remarks:
1. No more than one AXSLØT card is permitted.
 2. The default values are used on the GRIDS, SLBDY, CAXIFI, and CSLØTi data cards and must be nonzero as noted if these cards use the default.
 3. The harmonic index number N must be entered on this card.
 4. If the number of slots, M, is different in different regions or the cavity, this fact may be indicated on the CSLØTi and SLBDY cards. If the number of slots is zero, no matrices for CSLØTi elements are generated.
 5. A zero entry for bulk modulus is treated as if the fluid was incompressible.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card BARØR

Simple Beam Orientation Default

Description: Defines default values for fields 3 and 6-9 of the CBAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BARØR		PID			X1,G0	X2	X3	F	
BARØR		39			0.6	2.9	-5.87	1	

Field

Contents

PID Identification number of PBAR property card (Integer > 0 or blank)

X1, X2, X3 Vector components measured in displacement coordinate system at GA to determine (with the vector from end A to end B) the orientation of the element coordinate system for the bar element (Real or blank; see below)

G0 Grid point identification number (Integer > 0; see below)

F Flag to specify the nature of fields 6-8 as follows:

	6	7	8
F = 1	X1	X2	X3
F = 2	G0	blank	blank

- Remarks:
1. The contents of fields on this card will be assumed for any CBAR card whose corresponding fields are blank.
 2. Only one BARØR card may appear in the user's Bulk Data Deck.
 3. For an explanation of bar element geometry, see Section 1.3.2.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card BDYC

Combination of Substructure Boundary Sets

Description: Defines a combination of boundary sets by basic substructure to define a set of grid points and components which may be used in a REDUCE operation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BDYC	ID	NAME1	SID1	NAME2	SID2	NAME3	SID3		ghi
BDYC	157	WINGRT	7	MIDWG	15	FUSELAGE	32		GHI
+hi		NAMEi	SIDi	etc.					jk1
+HI		PØD1	175	WINGRT	15	CABIN	16		

Field

Contents

ID Identification number of combination boundary set (Integer > 0)

NAMEi Name of basic substructure which contains the grid points defined by boundary set SIDi (BCD)

SIDi Identification number of the boundary set associated with basic substructure NAMEi (Integer > 0)

- Remarks:
1. Boundary sets must be selected in the Substructure Control Deck (BØUNDARY=ID) to be used by NASTRAN. Note that 'BØUNDARY' is a subcommand of the substructure REDUCE command.
 2. The same substructure name may appear more than once per set.
 3. The SIDi numbers need not be unique. The same number could appear for different component structures.
 4. The SIDi numbers reference the set ID's of BDYS and BDYS1 cards.
 5. The ID number must be unique with respect to all other BDYC data cards.
 6. After two or more basic substructures are combined, the connected degrees of freedom are actually the same and may be referenced with any one of the substructure names. Redundant specification is allowed.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card BDYLIST

Fluid Boundary List

Description: Defines the boundary between a fluid and a structure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BDYLIST	RHØ	IDF1	IDF2	IDF3	IDF4	IDF5	IDF6	IDF7	abc
BDYLIST	.037	432	325	416	203	256	175	153	345A
+bc	IDF8	etc.							def
+45A	101	105	AXIS						

-etc.-

Field

Contents

RHØ Fluid mass density at boundary (Real \geq 0.0 or blank. Default on AXIF card is used if blank)

IDFi Identification number of a RINGFL point (Integer $>$ 0 or BCD. "AXIS" may be first and/or last entry on the logical card)

- Remarks:
1. This card is allowed only if an AXIF card is also present.
 2. Each logical card defines a boundary if RHØ \neq 0.0. The order of the points must be sequential with the fluid on the right with respect to the direction of travel.
 3. The BCD word, AXIS, defines an intersection with the polar axis of the fluid coordinate system.
 4. There may be as many BDYLIST cards as the user requires. If the fluid density varies along the boundary there must be one BDYLIST card for each interval between fluid points.
 5. The BDYLIST card is not required and should not be used to specify a rigid boundary where structural points are not defined. Such a boundary is automatically implied by the omission of a BDYLIST.
 6. If RHØ is 0.0, no boundary matrix terms will be generated to connect the GRIDB points to the fluid. This option is a convenience for structural plotting purposes. GRIDB points may be located on a fluid ring (RINGFL) only if the rings are included in a BDYLIST.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card BDYS Boundary Set Definition

Description: This card is used to define a boundary set of grid points and degrees of freedom for a basic substructure. The boundary set is used in the substructure REDUCE operation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BDYS	SID	G1	C1	G2	C2	G3	C3		
BDYS	7	13	123456	15	123	17	123456		

<u>Field</u>	<u>Contents</u>
--------------	-----------------

SID	Identification number of BDYS set (Integer > 0)
Gi	Grid or scalar point identification number of a basic substructure (Integer > 0)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.

Remarks:

1. The set of boundary points defines the degrees of freedom which are to be retained in the matrices after the substructure REDUCE operation has been performed. An alternate input format is provided by the BDYS1 card.
2. The SID need not be unique.
3. The BDYS card must be referenced by the BDYC card in order to attach the basic substructure name to the boundary set specified on the BDYS card. Note that the same BDYS boundary set may be attached to more than one basic substructure name.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card BDYS1

Boundary Set Definition

Description: This card is used to define a boundary set of grid points and degrees of freedom for a basic substructure. The boundary set is used in the substructure REDUCE operation.

Format and Examples:

1	2	3	4	5	6	7	8	9	10
BDYS1	SID	C	G1	G2	G3	G4	G5	G6	abc
BDYS1	15	123456	275	276	THRU	457	589	102	ABC
+bc	G7	G8	etc.		GN				
+BC	103	105			1275				

Field

Contents

SID Identification number of BDYS1 set (Integer > 0)

Ci Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.

Gi	Grid or scalar point identification number of a basic substructure (Integer > 0)
----	--

Remarks: 1. The set of boundary points defines the degrees of freedom which are to be retained in the matrices after the substructure REDUCE operation has been performed. An alternate format is provided by the BDYS card.

2. The "THRU" may appear in any field other than 2 and 9.

3. The SID need not be unique.

4. The BDYS1 card must be referenced by the BDYC card in order to attach the basic substructure name to the boundary set specified on the BDYS card. Note that the same BDYS boundary set may be attached to more than one basic substructure name.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CAERØ1 Aerodynamic Panel Element Connection

Description: Defines an aerodynamic macro element (panel) in terms of two leading edge locations and side chords.

Format and Example:

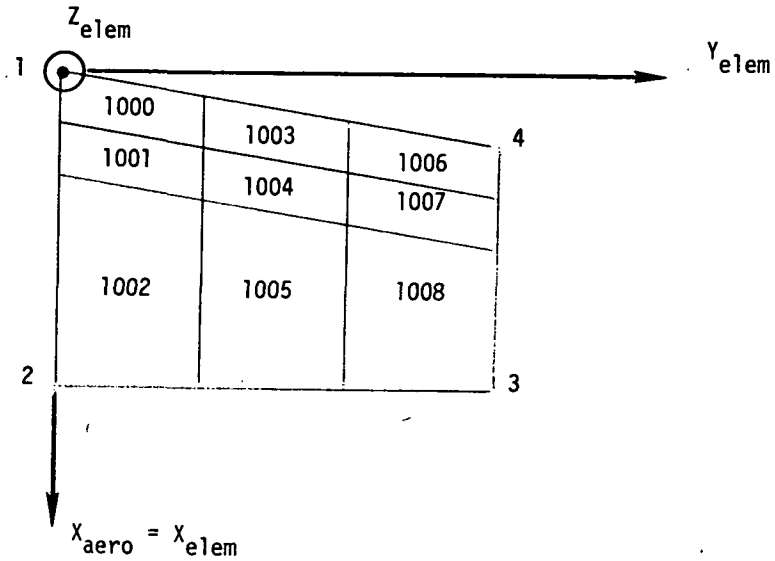
1	2	3	4	5	6	7	8	9	10
CAERØ1	EID	PID	CP	NSPAN	NCHØRD	LSPAN	LCHØRD	IGID	ABC
CAERØ1	1000	1		3			2	1	ABC
+BC	X1	Y1	Z1	X12	X4	Y4	Z4	X43	
+BC	0.0	0.0	0.0	1.0	0.2	1.0	0.0	0.8	

<u>Field</u>	<u>Contents</u>
EID	Element identification number (unique Integer > 0).
PID	Identification number of property card (Integer > 0).
CP	Coordinate system for locating points 1 and 4 (Integer ≥ 0).
NSPAN	Number of spanwise boxes; if a positive value is given, equal divisions are assumed; if zero or blank, a list of division points follows (Integer ≥ 0).
NCHØRD	Number of chordwise boxes (same rule as for NSPAN).
LSPAN	ID of an AEFACT data card containing a list of division points for spanwise boxes. Used only if field 5 is zero or blank (Integer > 0 if NSPAN is zero or blank).
LCHØRD	ID of an AEFACT data card containing a list of division points for chordwise boxes. Used only if field 6 is zero or blank (Integer > 0 if NCHØRD is zero or blank).
IGID	Interference group identification (aerodynamic elements with different IGID's are uncoupled) (Integer > 0).
X1,Y1,Z1;X4,Y4,Z4	Location of points 1 and 4, in coordinate system CP (Real).
X12; X43	Edge chord (in aerodynamic coordinate system) (Real ≥ 0, and not both zero).

NASTRAN DATA DECK

CAERØ1 (Cont.)

Remarks:



1. The boxes are numbered sequentially, beginning with EID. The user should be careful to ensure that all box numbers are unique, and different from structural grid ID's.
2. The number of division points is one greater than the number of boxes. Thus, if NSPAN = 3, the division points are 0.0, 0.333, 0.667, 1.000. If the user supplies division points, the first and last points need not be 0. and 1. (in which the corners of the panel would not be at the reference points).
3. A triangular element is formed if X_{12} or $X_{43} = 0$.
4. The element coordinate system (right-handed) is shown in the sketch.
5. The continuation card is required.

BULK DATA DECK

Input Data Card CAXIFi

Fluid Element Connections

Description: Defines an axisymmetric fluid element which connects $i = 2$, $i = 3$, or $i = 4$ fluid points.

Formats and Examples:

1	2	3	4	5	6	7	8	9	10
CAXIF2	EID	IDF1	IDF2			RHØ	B		
CAXIF2	11	23	25			.25E-03			
CAXIF3	EID	IDF1	IDF2	IDF3		RHØ	B		
CAXIF3	105	31	32	33			6.7E4		
CAXIF4	EID	IDF1	IDF2	IDF3	IDF4	RHØ	B		
CAXIF4	524	421	425	424	422	.5-3	2.5+3		

Field

Contents

EID	Element identification number (Integer > 0)
IDFj	Identification numbers of connected GRIDF points, $j = 1, 2, \dots, i$ (Integer > 0)
RHØ	Fluid density in mass units (Real > 0.0 or blank)
B	Fluid bulk modulus (Real \geq 0.0 or blank)

- Remarks:
1. This card is allowed only if an AXSLØT card is also present.
 2. The element identification number (EID) must be unique with respect to all other fluid or structural elements.
 3. If RHØ, or B are "blank" the corresponding values on the AXSLØT data card are used, in which case the default must not be blank (undefined).
 4. Plot elements are generated for these elements. Because each plot element connects two points, one is generated for the CAXIF2 element, three are generated for the CAXIF3 element, and four plot elements are generated for the CAXIF4 element. In the last case the elements connect the pairs of points (1-2), (2-3), (3-4) and (4-1).
 5. If $B = 0.0$, the fluid is considered to be incompressible.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CBAR

Simple Beam Element Connection

Description: Defines a simple beam element (BAR) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CBAR	EID	PID	GA	GB	X1,G0	X2	X3	F	abc
CBAR	2	39	7	3	13			2	123
+bc	PA	PB	Z1A	Z2A	Z3A	Z1B	Z2B	Z3B	
+23		513							

Field

Contents

EID Unique element identification number (Integer > 0)

PID Identification number of a PBAR property card (Default is EID unless BARØR card has nonzero entry in field 3) (Integer > 0 or blank*)

GA,GB Grid point identification numbers of connection points (Integer > 0; GA ≠ GB)

X1,X2,X3 Components of vector \vec{v} , at end a, (figure 1(a) on page 1.3-15) measured at end a, parallel to the components of the displacement coordinate system for GA, to determine (with the vector from end a to end b) the orientation of the element coordinate system for the bar element (Real, $X1^2 + X2^2 + X3^2 > 0$ or blank*, see below).

G0 Grid point identification number to optionally supply X1, X2, X3 (integer > 0 or blank*) (see below)

F Flag to specify the nature of fields 6-8 as follows:

	6	7	8
F = blank*			
F = 1	X1	X2	X3
F = 2	G0	blank/0	blank/0

PA,PB Pin flags for bar ends a and b, respectively, that are used to insure that the bar cannot resist a force or moment corresponding to the pin flag at that respective end of the bar. (Up to 5 of the unique digits 1-6 anywhere in the field with no imbedded blanks; integer > 0) (These degree of freedom codes refer to the element forces and not global forces. The bar must have stiffness associated with the pin flag. For example, if pin flag 4 is specified, the bar must have a value for J, the torsional constant.)

Z1A,Z2A,Z3A Components of offset vectors \vec{w}_a and \vec{w}_b , respectively, (see figure 1(a), page 1.3-15) in displacement coordinate systems at points GA and GB, respectively. (Real or blank)

*See the BARØR card for default options for fields 3, 6, 7, 8 and 9.

NASTRAN DATA DECK

CBAR (Cont.)

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. For an explanation of bar element geometry, see Section 1.3.2.
 3. Zero (0) must be used in fields 7 and 8 in order to override entries in these fields associated with $F = 1$ in field 9 on a BARØR card.
 4. If there are no pin flags or offsets, the continuation card may be omitted.

BULK DATA DECK

Input Data Card CCØNEAX

Axisymmetric Shell Element Connection

Description: Defines the connection of a conical shell element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CCØNEAX	ID	PID	RA	RB					
CCØNEAX	1	2	3	4					

Field

Contents

EID Unique element identification number (Integer > 0)
 PID Identification number of a PCØNEAX card (Default is EID) (Integer > 0)
 RA Identification number of a RINGAX card (Integer > 0; RA ≠ RB)
 RB Identification number of a RINGAX card (Integer > 0; RA ≠ RB)

Remarks: 1. This card is allowed if and only if an AXIC card is also present.
 2. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CDAMP1

Scalar Damper Connection

Description: Defines a scalar damper element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP1	EID	PID	G1	C1	G2	C2			
CDAMP1	19	6	0		23	2			

Field

Contents

EID	Unique element identification number (Integer > 0)
PID	Identification number of a PDAMP property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer ≥ 0)
C1, C2	Component number (6 ≥ Integer ≥ 0)

- Remarks:
1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CDAMP3 card.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. The two connection points, (G1, C1) and (G2, C2), must be distinct.
 4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CDAMP2

Scalar Damper Property and Connection

Description: Defines a scalar damper element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP2	EID	B	G1	C1	G2	C2			
CDAMP2	16	-2.98	32	1					

Field

Contents

EID Unique element identification number (Integer > 0)
 B The value of the scalar damper (Real)
 G1, G2 Geometric grid point identification number (Integer ≥ 0)
 C1, C2 Component number (6 ≥ Integer ≥ 0)

- Remarks:
1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CDAMP4 card.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. This single card completely defines the element since no material or geometric properties are required.
 4. The two connection points, (G1, C1) and (G2, C2), must be distinct.
 5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

NASTRAN DATA DECK

Page 1 of 1

BULK DATA DECK

Input Data Card CDAMP3

Scalar Damper Connection

Description: Defines a scalar damper element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP3	EID	PID	S1	S2	EID	PID	S1	S2	
CDAMP3	16	978	24	36	17	978	24	37	

Field

Contents

EID Unique element identification number (Integer > 0)
 PID Identification number of a PDAMP property card (Default is EID) (Integer > 0)
 S1, S2 Scalar point identification numbers (Integer ≥ 0; S1 ≠ S2)

- Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. One or two scalar damper elements may be defined on a single card.
 4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CDAMP4

Scalar Damper Property and Connection

Description: Defines a scalar damper element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP4	EID	B	S1	S2	EID	B	S1	S2	
CDAMP4	16	-2.6	4	9	17	+8.6	3	7	

<u>Field</u>	<u>Contents</u>
EID	Unique element identification number (Integer > 0)
B	The scalar damper value (Real)
S1, S2	Scalar point identification numbers (Integer ≥ 0 ; S1 \neq S2)

- Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. This card completely defines the element since no material or geometric properties are required.
 4. One or two scalar damper elements may be defined on a single card.
 5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CDUMi

Dummy Element Connection

Description: Defines a dummy element ($1 \leq i \leq 9$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDUMi	EID	PID	G1	G2	G3	G4	-etc.-	GN	abc
CDUM2	114	108	2	5	6	8		11	ABC
+bc	A1	A2	-etc.-			AN			
+BC	2.4		3.E4	2		50			

Field

Contents

EID Element identification number (Integer > 0)

PID Identification number of a PDUMi property card (Integer > 0)

G1...GN Grid point identification numbers of connection points (Integer > 0,
G1 ≠ G2 ... ≠ GN)

A1...AN Additional entries (Real or Integer)

- Remarks:
1. The user must code the associated element routines for matrix generation, stress recovery, etc., and perform a link edit to replace the dummy routines.
 2. If no property card is required, field 3 may contain the material identification number.
 3. Additional entries are defined in the user written element routines.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CELAS1 Scalar Spring Connection

Description: Defines a scalar spring element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS1	EID	PID	G1	C1	G2	C2			
CELAS1	2	6			8	1			

<u>Field</u>	<u>Contents</u>
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PELAS property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer > 0)
C1, C2	Component number ($6 \geq \text{Integer} \geq 0$)

- Remarks:
1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CELAS3 card.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. The two connection points, (G1, C1) and (G2, C2), must be distinct.
 4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CELAS2

Scalar Spring Property and Connection

Description: Defines a scalar spring element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS2	EID	K	G1	C1	G2	C2	GE	S	
CELAS2	28	6.2+3	32		19	4			

Field

Contents

EID	Unique element identification number (Integer > 0)
K	The value of the scalar spring (Real)
G1, G2	Geometric grid point identification number (Integer \geq 0)
C1, C2	Components number (6 \geq Integer \geq 0)
GE	Damping coefficient (Real)
S	Stress coefficient (Real)

- Remarks:
1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CELAS4 card.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. This single card completely defines the element since no material or geometric properties are required.
 4. The two connection points, (G1, C1) and (G2, C2), must be distinct.
 5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CELAS3

Scalar Spring Connection

Description: Defines a scalar spring element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS3	EID	PID	S1	S2	EID	PID	S1	S2	
CELAS3	19	2	14	15	2	3	0	28	

Field

Contents

EID Unique element identification number (Integer > 0)
 PID Identification number of a PELAS property card (Default is EID) (Integer > 0)
 S1, S2 Scalar point identification numbers (Integer \geq 0; S1 \neq S2)

Remarks:

1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. One or two scalar springs may be defined on a single card.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CELAS4

Scalar Spring Property and Connection

Description: Defines a scalar element of the structural model which is connected only to scalar points without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS4	EID	K	S1	S2	EID	K	S1	S2	
CELAS4	42	6.2-3	2		13	6.2-3	0	2	

<u>Field</u>	<u>Contents</u>
EID	Unique element identification number (Integer > 0)
K	The scalar spring value (Real)
S1, S2	Scalar point identification numbers (Integer ≥ 0 ; S1 \neq S2)

- Remarks:
1. S1 or S2 but not both may be blank or zero indicating a constrained coordinate.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. This card completely defines the element since no material or geometric properties are required.
 4. No damping coefficient is available with this form. (Assumed to be 0.0)
 5. No stress coefficient is available with this form.
 6. One or two scalar springs may be defined on a single card.
 7. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CFLUIDi

Fluid Element Connections

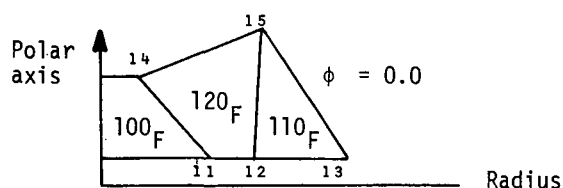
Description: Defines three types of fluid elements for axisymmetric fluid model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CFLUID2	EID	IDF1	IDF2			RHØ	B		
CFLUID2	100	11	14			.025	0.0		
CFLUID3	EID	IDF1	IDF2	IDF3		RHØ	B		
CFLUID3	110	15	13	12		1.2			
CFLUID4	EID	IDF1	IDF2	IDF3	IDF4	RHØ	B		
CFLUID4	120	11	15	12	14				

Field	Contents
EID	Element identification number (Integer, $0 < Id_c < 10^5$)
IDFi	Identification number of RINGFL card (Integer > 0 ; $IDF1 \neq IDF2 \neq IDF3 \neq IDF4$)
RHØ	Mass density (Real > 0.0 or blank; If blank, the AXIF default value is used)
B	Bulk modulus, pressure per volume ratio (Real or blank. Default value on AXIF card is used if blank)

- Remarks:
1. This card is allowed only if an AXIF card is also present.
 2. Element identification number must be unique with respect to all other fluid, scalar and structural elements.
 3. The volume defined by IDFi is a body of revolution about the polar axis of the Fluid Coordinate System defined by AXIF. CFLUID2 defines a thick disk with IDF1 and IDF2 defining the outer corners as in the sketch.



4. All interior angles must be less than 180° .
5. The order of connected RINGFL points is arbitrary.
6. If the bulk modulus value is zero the fluid is assumed incompressible.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CHBDY

Heat Boundary Element

Description: Defines a boundary element for heat transfer analysis which is used for heat flux, thermal vector flux, convection and/or radiation.

Format and Example:

1	2	3	4	5	6	7	8		
CHBDY	EID	PID	TYPE	G1	G2	G3	G4		
CHBDY	721	100	LINE	101	98				+BD721
+abc	GA1	GA2	GA3	GA4	V1	V2	V3		
+BD721	102	102			1.00	0.0	0.0		

<u>Field</u>	<u>Contents</u>
EID	Element identification number (Integer > 0)
PID	Property identification number (Integer > 0)
TYPE	Type of area involved (must be one of "PØINT", "LINE", "REV", "AREA3", "AREA4" or "ELCYL")
G1,G2,G3,G4	Grid point identification numbers of primary connected points (Integer > 0 or blank)
GA1,GA2,GA3,GA4	Grid or scalar point identification numbers of associated ambient points (Integer > 0 or blank)
V1,V2,V3	Vector (in the basic coordinate system) used for element orientation (real or blank)

Remarks:

1. The continuation card is not required.
2. The six types have the following characteristics:
 - a. The "PØINT" type has one primary grid point, requires a property card, and the normal vector {V1,V2,V3} must be given if thermal vector flux is to be used.
 - b. The "LINE" type has two primary grid points, requires a property card, and the vector is required if thermal vector flux is to be used.
 - c. The "REV" type has two primary grid points which must lie in the x-z plane of the basic coordinate system with $x > 0$. The defined area is a conical section with z as the axis of symmetry. A property card is required for convection, radiation, or thermal vector flux.
 - d. The "AREA3" and "AREA4" types have three and four primary grid points, respectively. These points define a triangular or quadrilateral surface and must be ordered to go around the boundary. A property card is required for convection, radiation, or thermal vector flux.
 - e. The "ELCYL" type (elliptic cylinder) has two connected primary grid points, it requires a property card, and if thermal vector flux is used, the vector must be nonzero.

NASTRAN DATA DECK

CHBDY (Cont.)

3. A property card, PHBDY, is used to define the associated area factors, the emissivity, the absorbtivity, and the principal radii of the elliptic cylinder. The material coefficients used for convection and thermal capacity are referenced by the PHBDY card. See this card description for details.
4. The associated points, GA1, GA2, etc., may be either grid or scalar points, and are used to define the ambient temperature for a convection field. These points correspond to the primary points G1, G2, etc., and the number of them depends on the TYPE option, but they need not be unique. Their values may be set in statics with an SPC card, or they may be connected to other elements. If any field is blank, the ambient temperature associated with that grid point is assumed to be zero.
5. Heat flux may be applied to this element with QBDY1 or QBDY2 cards.
6. Thermal vector flux from a directional source may be applied to this element with a QVECT card. See Figure 1 on page 1.8-7 for the definition of the normal vector for each element type.

BULK DATA DECK

Input Data Card CHEXAi

Hexahedron Element Connection

Description: Defines two types of hexahedron elements (3 dimensional solid with 8 vertices and 6 quadrilateral faces, HEXAi) of the structural model.

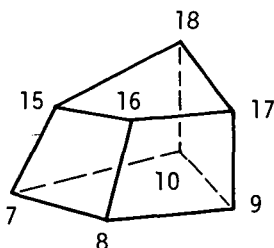
Format and Example:

1	2	3	4	5	6	7	8	9	10
CHEXAi	EID	MID	G1	G2	G3	G4	G5	G6	abc
CHEXA2	15	2	7	8	9	10	15	16	ABC
+bc	G7	G8							
+BC	17	18							

Field

Contents

CHEXAi CHEXA1 or CHEXA2 (see Remark 7)
 EID Element identification number (Integer > 0)
 MID Material identification number (Integer > 0)
 G1,...,G8 Grid point identification numbers of connection points (Integers > 0, G1 ≠ G2 ≠ ... ≠ G8)



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. The order at the grid points is: G1, G2, G3, G4 in order around one quadrilateral face. G5, G6, G7, G8 are in order in the same direction around the opposite quadrilateral, with G1 and G5 along the same edge.
 3. The quadrilateral faces must be nearly planar.
 4. There is no nonstructural mass.
 5. For structural problems, material must be defined by MAT1 card.
 6. Stresses are given in the basic coordinate system.
 7. CHEXA1 represents the element as 5 tetrahedra, CHEXA2 represents the element as 10 overlapping tetrahedra.
 8. For heat transfer problems, material may be defined with either a MAT4 or MAT5 card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CIHEX1

Linear Isoparametric Hexahedron Element Connection

Description: Defines a linear isoparametric hexahedron element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CIHEX1	EID	PID	G1	G2	G3	G4	G5	G6	abc
CIHEX1	137	5	3	8	5	4	9	14	ABC
+bc	G7	G8							
+BC	11	10							

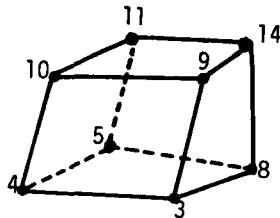
Field

Contents

EID Element identification number (Integer > 0)

PID Identification number of a PIHEX property card (Integer > 0)

G1,...,G8 Grid point identification numbers of connection points (Integer > 0,
G1 ≠ G2 ≠ ... ≠ G8)



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1, G2, G3, G4 must be given in counter-clockwise order about one quadrilateral face when viewed from inside the element. G5, G6, G7, G8 are in order in the same direction around the opposite quadrilateral, with G1 and G5 along the same edge.
 3. There is no non-structural mass.
 4. The quadrilateral faces need not be planar.
 5. Stresses are given in the basic coordinate system.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CIHEX2

Quadratic Isoparametric Hexahedron Element Connection

Description: Defines a quadratic isoparametric hexahedron element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CIHEX2	EID	PID	G1	G2	G3	G4	G5	G6	abc
CIHEX2	110	7	3	8	12	13	14	9	ABC
+bc	G7	G8	G9	G10	G11	G12	G13	G14	def
+BC	5	4	16	19	20	17	23	27	DEF
+ef	G15	G16	G17	G18	G19	G20			
+EF	31	32	33	28	25	24			

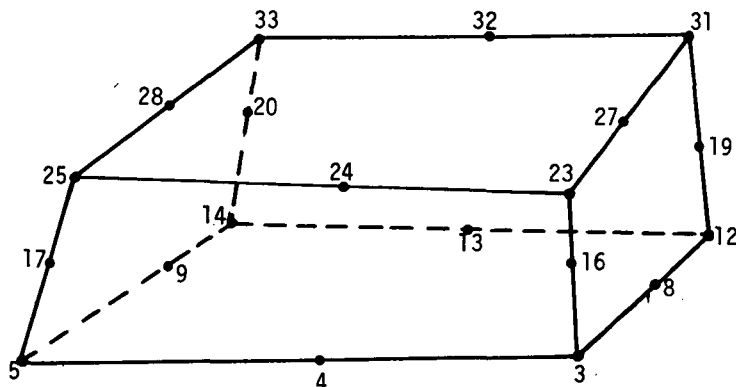
Field

Contents

EID Element identification number (Integer > 0)

PID Identification number of a P1HEX property card (Integer > 0)

G1,...,G20 Grid point identification numbers of connection points (Integer > 0,
G1 ≠ G2 ≠ ... ≠ G20)



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1,...,G8 must be given in counter-clockwise order about one quadrilateral face when viewed from inside the element. G9,...,G12 and G13,...,G20 are in the same direction with G1, G9 and G13 along the same edge.
 3. There is no nonstructural mass.
 4. The quadrilateral faces need not be planar.
 5. Stresses are given in the basic coordinate system.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CIHEX3

Cubic Isoparametric Hexahedron Element Connection

Description: Defines a cubic isoparametric hexahedron element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CIHEX3	EID	PID	G1	G2	G3	G4	G5	G6	abc
CIHEX3	15	3	4	9	12	17	18	19	ABC
+bc	G7	G8	G9	G10	G11	G12	G13	G14	def
+BC	20	13	10	7	6	5	22	25	DEF
+ef	G15	G16	G17	G18	G19	G20	G21	G22	ghi
+EF	26	23	28	31	32	29	36	41	GHI
+hi	G23	G24	G25	G26	G27	G28	G29	G30	jkl
+HI	44	49	50	51	52	45	42	39	JKL
+kl	G31	G32							
+KL	38	37							

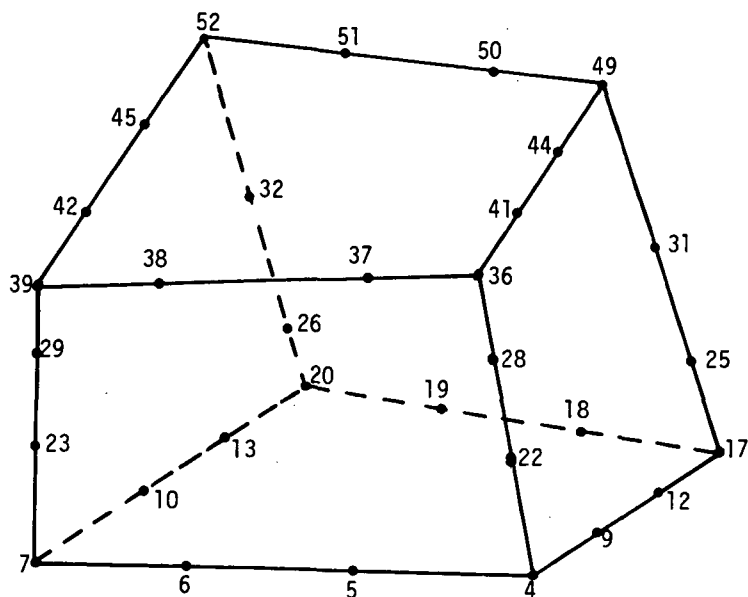
Field

Contents

EID Element identification number (Integer > 0)

PID Identification number of a PIHEX property card (Integer > 0)

G1,...,G32 Grid point identification number of connection points (Integer > 0, G1 ≠ G2 ≠ ... ≠ G32)



NASTRAN DATA DECK

CIHEX3 (Cont.)

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1,...,G12 must be given in counter-clockwise order about one quadrilateral face when viewed from inside the element. G13,...,G16; G17,...,G20; and G21,...,G32 are in the same direction with G1, G13, G17, G21 along the same edge.
 3. There is no nonstructural mass.
 4. The quadrilateral faces need not be planar.
 5. Stresses are given in the basic coordinate system.

BULK DATA DECK

Input Data Card CMASS1 Scalar Mass Connection

Description: Defines a scalar mass element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS1	EID	PID	G1	C1	G2	C2			
CMASS1	32	6	2	1	2	3			

Field

Contents

EID	Unique element identification number (Integer > 0)
PID	Identification number of a PMASS property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer ≥ 0)
C1, C2	Component number (6 ≥ Integer ≥ 0)

- Remarks:
1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CMASS3 card.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. The two connection points, (G1, C1) and (G2, C2), must be distinct.
 4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CMASS2

Scalar Mass Property and Connection

Description: Defines a scalar mass element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS2	EID	M	G1	C1	G2	C2			
CMASS2	32	9.25	6	1	7				

Field

Contents

EID	Unique element identification number (Integer > 0)
M	The value of the scalar mass (Real)
G1, G2	Geometric grid point identification number (Integer ≥ 0)
C1, C2	Component number (6 ≥ Integer ≥ 0)

- Remarks:
1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CMASS4 card.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. This card completely defines the element since no material or geometric properties are required.
 4. The two connection points, (G1, C1) and (G2, C2), must be distinct.
 5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

* A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CMASS3

Scalar Mass Connection

Description: Defines a scalar mass element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS3	EID	PID	S1	S2	EID	PID	S1	S2	
CMASS3	13	42	62	1					

Field

Contents

EID Unique element identification number (Integer > 0)
 PID Identification number of a PMASS property card (Default is EID) (Integer > 0)
 S1, S2 Scalar point identification numbers (Integer ≥ 0; S1 ≠ S2)

- Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. One or two scalar masses may be defined on a single card.
 4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CMASS4

Scalar Mass Property and Connection

Description: Defines a scalar mass element of the structural model which is connected only to scalar points without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CMASS4	EID	M	S1	S2	EID	M	S1	S2	
CMASS4	23	14.92	6	23	2	-16.3	0	29	

Field

Contents

EID Unique element identification number (Integer > 0)
M The scalar mass value (Real)
S1, S2 Scalar point identification numbers (Integer ≥ 0 ; S1 \neq S2)

- Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. This card completely defines the element since no material or geometric properties are required.
 4. One or two scalar masses may be defined on a single card.
 5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CNGRNT

Identical Elements Indicator

Description: Designates secondary element(s) identical to a primary element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CNGRNT	PRID	SECID1	SECID2	SECID3	SECID4	SECID5	SECID6	SECID7	abc
CNGRNT	11	2	17	34	35	36			

+bc	SECID8	SECID9		-etc.-					

Alternate Form

CNGRNT	PRID	SECID1	"THRU"	SECID2					
CNGRNT	7	2	THRU	55					

Field

Contents

PRID Identification number of the primary element (not necessarily the lowest number) for which the stiffness, mass and damping matrices will be calculated.

SECIDi Identification number(s) of secondary element(s) whose matrices will be identical to the primary element.

- Remarks:
1. Orientation, geometry, etc. must be truly identical such that the same stiffness, mass and damping matrices are generated in the global coordinate system.
 2. This feature is automatically used by the INPUT module.
 3. An element that has been listed as a primary element on any CNGRNT card cannot be listed as a secondary element either on that card or on any other CNGRNT card.
 4. The CNGRNT feature cannot be used when an AXIC card is present in the bulk data deck.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CØNCT Substructure Connectivity

Description: Defines the grid point and degree of freedom connectivities between two substructures for a manual CØMBINE operation.

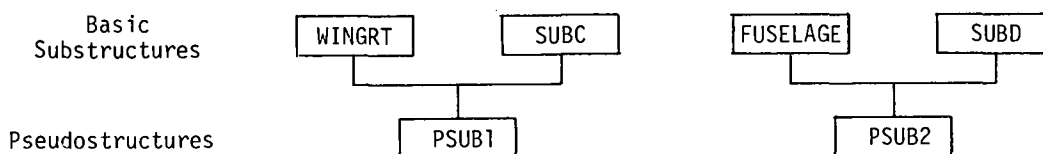
Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNCT	SID	C	SUBA	SUBB					def
CØNCT	307	1236	WINGRT	FUSELAGE					DEF
+ef	GA1	GB1	GA2	GB2	GA3	GB3	GA4	GB4	hij
+EF	201	207	958	214	971	216	982		HIJ

<u>Field</u>	<u>Contents</u>
SID	Identification number of connectivity set (Integer > 0)
C	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.
SUBA, SUBB	Names of basic substructures being connected (BCD).
GAi, GBi	Grid or scalar point identification numbers GAi from SUBA connects to GBi from SUBB by the degrees of freedom specified in C (Integer > 0)

- Remarks:
- At least one continuation card must be present.
 - Components specified on a CØNCT card will be overridden by RELES cards.
 - Several CØNCT and CØNCT1 cards may be input with the same value of SID.
 - An alternate format is given by the CØNCT1 data card.
 - Connectivity sets must be selected in the Substructure Control Deck (CØNNECT=SID) to be used by NASTRAN. Note that 'CØNNECT' is a subcommand of the substructure CØMBINE command.
 - SUBA and SUBB must be component basic substructures of the pseudostructures being combined as specified on the substructure CØMBINE command card. SUBA and SUBB must not be components of the same pseudostructure.

In the figure below, a substructure "tree" and a set of substructure command cards are shown. The CØNNECT subcommand references the example CØNCT card above. In this example, pseudostructure PSUB1 and PSUB2 are combined and connected only at points in their respective basic component substructures WINGRT and FUSELAGE.



NASTRAN DATA DECK

CØNCT (Cont'd)

CØMBINE(MANUAL) PSUB1,PSUB2

NAME = PPSUB

TØLER = 0.01

CØNNECT = 307.

BULK DATA DECK

Input Data Card CØNCT1 Substructure Connectivity

Description: Defines the grid point and degree of freedom connectivities between two or more substructures for a manual CØMBINE operation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNCT1	SID	NAME1	NAME2	NAME3	NAME4	NAME5	NAME6	NAME7	def
CØNCT1	805	WINGRT	FUSELAGE	MIDWG	PØD				DEF
+ef	C1	G11	G12	G13	G14	G15	G16	G17	hij
+EF	123	528	17	32	106				HIJ
+ij	C2	G21	G22	G23	G24	G25	G26	G27	
+IJ	46	518							etc.

Field

Contents

SID Identification number of connectivity set (Integer > 0)

NAMEi Basic substructure name (BCD)

Ci Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.

Gij Grid or scalar point identification number in substructure namei with components Ci (Integer > 0)

- Remarks:**
1. As least one continuation card must be present.
 2. Components specified on CØNCT1 card will not be overridden by RELES cards.
 3. Several CØNCT and CØNCT1 cards may be input with the same value of SID.
 4. An alternate format is given by the CØNCT card.
 5. Connectivity sets must be selected in the Substructure Control Deck (CØNNECT=SID) to be used by NASTRAN. Note that 'CØNNECT' is a subcommand of the substructure CØMBINE command.
 6. The NAMEi's must be the names of basic substructure components of the pseudostructures named on the CØMBINE card in the Substructure Control Deck. See the CØNCT card for a more complete discussion related to the combination of two substructures.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CØNM1

Concentrated Mass Element Connection

Description: Defines a 6x6 symmetric mass matrix at a geometric grid point of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNM1	EID	G	CID	M11	M21	M22	M31	M32	abc
CØNM1	2	22	2	2.9		6.3			+1
+bc	M33	M41	M42	M43	M44	M51	M52	M53	def
+1	4.8				28.6				+2
+ef	M54	M55	M61	M62	M63	M64	M65	M66	
+2		28.6						28.6	

Field

Contents

EID Unique element identification number (Integer > 0)
 G Grid point identification number (Integer > 0)
 CID Coordinate system identification number for the mass matrix (Integer ≥ 0)
 Mij Mass matrix values (Real)

Remarks: 1. For a less general means of defining concentrated mass at grid points, see CØNM2.
 2. Element identification numbers must be unique with respect to all other element identification numbers.

NASTRAN DATA DECK

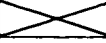
BULK DATA DECK

Input Data Card CØNM2

Concentrated Mass Element Connection

Description: Defines a concentrated mass at a grid point of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNM2	EID	G	CID	M	X1	X2	X3		abc
CØNM2	2	15	6	49.7					123
+bc	I11	I21	I22	I31	I32	I33			
+23	16.2		16.2			7.8			

Field

Contents

EID	Element identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
CID	Coordinate system identification number (Integer ≥ 0)
M	Mass Value (Real)
X1,X2,X3	Offset distances for the mass in the coordinate system defined in field 4 (Real)
Iij	Mass moments of inertia measured at the mass c.g. in coordinate system defined by field 4 (Real)

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. For a more general means of defining concentrated mass at grid points, see CØNM1.
 3. The continuation card may be omitted.
 4. The form of the inertia matrix about its c.g. is taken as:

$$\begin{bmatrix}
 M & & & 0 & zM & -yM \\
 & M & & -zM & 0 & xM \\
 & & M & yM & -xM & 0 \\
 & & & I11 & -I21 & -I31 \\
 & & & & I22 & -I32 \\
 & & & & & I33
 \end{bmatrix}$$

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CØNRØD

Rod Element Property and Connection

Description: Defines a rod element of the structural model without reference to a property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNRØD	EID	G1	G2	MID	A	J	C	NSM	
CØNRØD	2	16	17	23	2.69				

<u>Field</u>	<u>Contents</u>
EID	Unique element identification number (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)
MID	Material identification number (Integer > 0)
A	Area of rod (Real)
J	Torsional constant (Real)
C	Coefficient for torsional stress determination (Real)
NSM	Nonstructural mass per unit length (Real)

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. For structural problems, CØNRØD cards may only reference MAT1 material cards.
 3. For heat transfer problems, CØNRØD cards may only reference MAT4 or MAT5 material cards.

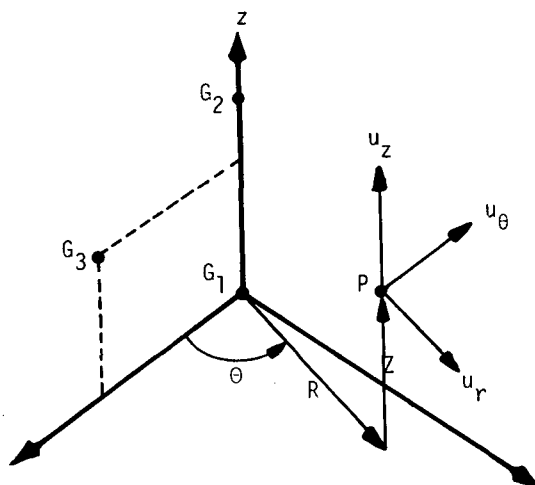
NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CØRD1C

Cylindrical Coordinate System Definition

Description: Defines a cylindrical coordinate system by reference to three grid points. These points must be defined in coordinate systems whose definition does not involve the coordinate system being defined. The first point is the origin, the second lies on the z-axis, and the third lies in the plane of the azimuthal origin.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD1C	CID	G1	G2	G3	CID	G1	G2	G3	
CØRD1C	3	16	32	19					

Field

Contents

CID Coordinate system identification number (Integer > 0)
G1, G2, G3 Grid point identification numbers (Integer > 0; $G1 \neq G2 \neq G3$)

- Remarks:
1. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
 2. The three points $G1$, $G2$, $G3$ must be noncollinear.
 3. The location of a grid point (P in the sketch) in this coordinate system is given by (R, θ, Z) where θ is measured in degrees.
 4. The displacement coordinate directions at P are dependent on the location of P as shown above by (u_r, u_θ, u_z) .
 5. Points on the z -axis may not have their displacement directions defined in this coordinate system since an ambiguity results.
 6. One or two coordinate systems may be defined on a single card.

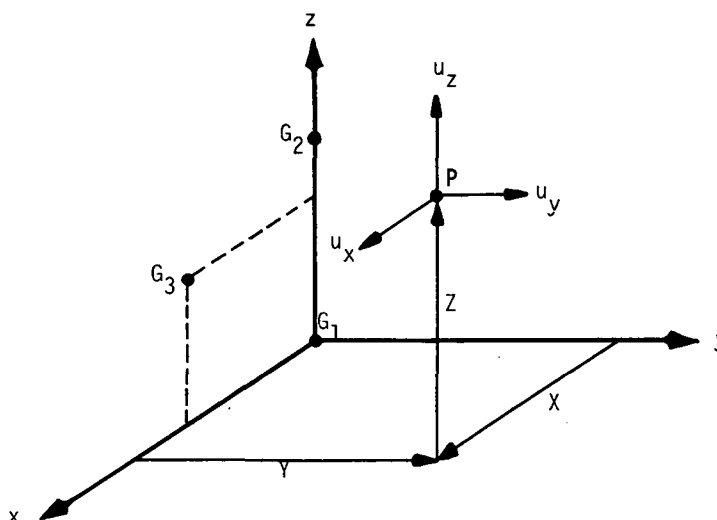
NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CØRD1R

Rectangular Coordinate System Definition

Description: Defines a rectangular coordinate system by reference to three grid points. These points must be defined in coordinate systems whose definition does not involve the coordinate system being defined. The first point is the origin, the second lies on the z-axis, and the third lies in the x-z plane.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD1R	CID	G1	G2	G3	CID	G1	G2	G3	
CØRD1R	3	16	32	19					

FieldContents

CID Coordinate system identification number (Integer > 0)
 G1, G2, G3 Grid point identification numbers (Integer > 0; G1 ≠ G2 ≠ G3)

- Remarks:
1. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
 2. The three points G1, G2, G3 must be noncollinear.
 3. The location of a grid point (P in the sketch) in this coordinate system is given by (X, Y, Z).
 4. The displacement coordinate directions at P are shown above by (u_x , u_y , u_z).
 5. One or two coordinate systems may be defined on a single card.

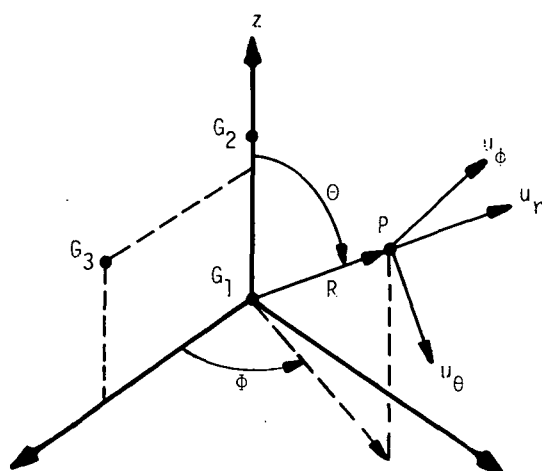
NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CØRD1S

Spherical Coordinate System Definition

Description: Defines a spherical coordinate system by reference to three grid points. These points must be defined in coordinate systems whose definition does not involve the coordinate system being defined. The first point is the origin, the second lies on the z-axis, and the third lies in the plane of the azimuthal origin.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD1S	CID	G1	G2	G3	CID	G1	G2	G3	
CØRD1S	3	16	32	19					

Field	Contents
CID	Coordinate system identification number (Integer > 0)
G1, G2, G3	Grid point identification numbers (Integer > 0; G1 ≠ G2 ≠ G3)

- Remarks:
1. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
 2. The three points G1, G2, G3 must be noncollinear.
 3. The location of a grid point (P in the sketch) in this coordinate system is given by (R, θ , ϕ) where θ and ϕ are measured in degrees.
 4. The displacement coordinate directions at P are dependent on the location of P as shown above by (u_r , u_θ , u_ϕ).
 5. Points on the polar axis may not have their displacement directions defined in this coordinate system since an ambiguity results.
 6. One or two coordinate systems may be defined on a single card.

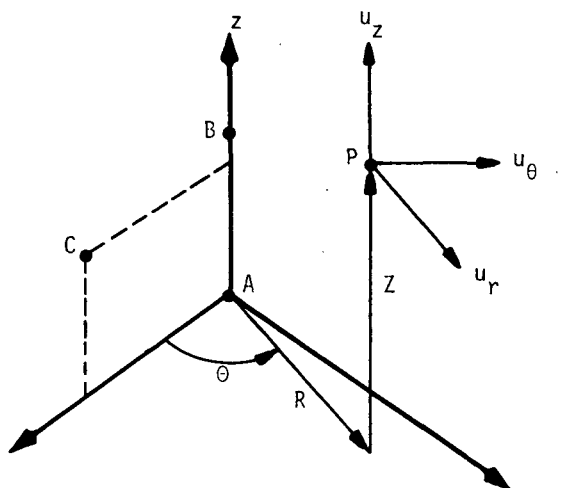
NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CØRD2C

Cylindrical Coordinate System Definition

Description: Defines a cylindrical coordinate system by reference to the coordinates of three points. The first point defines the origin. The second point defines the direction of the z-axis. The third lies in the plane of the azimuthal origin. The reference coordinate must be independently defined.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD2C	CID	RID	A1	A2	A3	B1	B2	B3	ABC
CØRD2C	3	17	-2.9	1.0	0.0	3.6	0.0	1.0	123
+BC	C1	C2	C3						
+23	5.2	1.0	-2.9						

Field

Contents

CID Coordinate system identification number (Integer > 0)

RID Reference to a coordinate system which is defined independently of new coordinate system (Integer ≥ 0 or blank)

A1,A2,A3
B1,B2,B3
C1,C2,C3 Coordinates of three points in coordinate system defined in field 3 (Real)

(continued)

NASTRAN DATA DECK

CØRD2C (Cont.)

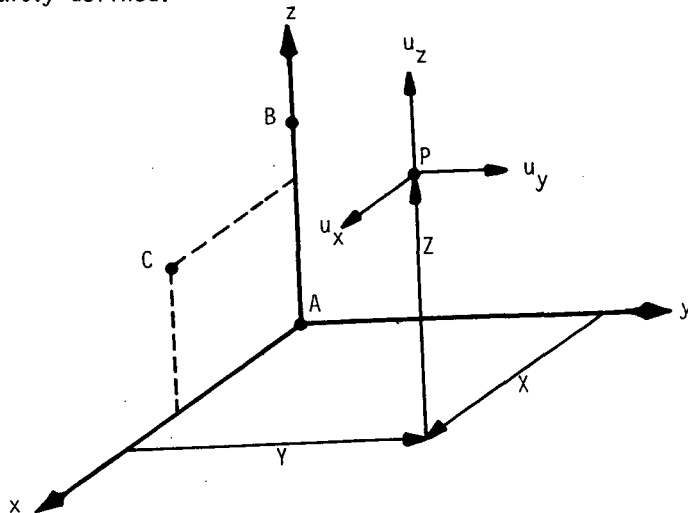
- Remarks:
1. Continuation card must be present.
 2. The three points (A1, A2, A3), (B1, B2, B3), (C1, C2, C3) must be unique and non-collinear. Noncollinearity is checked by the geometry processor.
 3. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
 4. An RID of zero references the basic coordinate system.
 5. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ , Z) where Θ is measured in degrees.
 6. The displacement coordinate directions at P are dependent on the location of P as shown above by (u_r , u_θ , u_z).
 7. Points on the z-axis may not have their displacement direction defined in this coordinate system since an ambiguity results.

BULK DATA DECK

Input Data Card CØRD2R

Rectangular Coordinate System Definition

Description: Defines a rectangular coordinate system by reference to the coordinates of three points. The first point defines the origin. The second point defines the direction of the z-axis. The third point defines a vector which, with the z-axis, defines the x-z plane. The reference coordinate must be independently defined.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD2R	CID	RID	A1	A2	A3	B1	B2	B3	ABC
CØRD2R	3	17	-2.9	1.0	0.0	3.6	0.0	1.0	123
+BC	C1	C2	C3						
+23	5.2	1.0	-2.9						

Field

Contents

CID Coordinate system identification number (Integer > 0)

RID Reference to a coordinate system which is defined independently of new coordinate system (Integer ≥ 0 or blank)

A1,A2,A3
B1,B2,B3
C1,C2,C3 Coordinates of three points in coordinate system defined in field 3 (Real)

- Remarks:
1. Continuation card must be present.
 2. The three points (A1, A2, A3), (B1, B2, B3), (C1, C2, C3) must be unique and non-collinear. Noncollinearity is checked by the geometry processor.
 3. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
 4. An RID of zero references the basic coordinate system.
 5. The location of a grid point (P in the sketch) in this coordinate system is given by (X, Y, Z).
 6. The displacement coordinate directions at P are shown by (u_x , u_y , u_z).

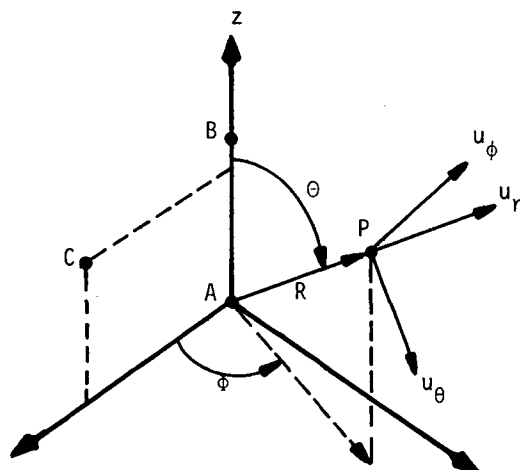
NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CØRD2S

Spherical Coordinate System Definition

Description: Defines a spherical coordinate system by reference to the coordinates of three points. The first point defines the origin. The second point defines the direction of the z-axis. The third lies in the plane of the azimuthal origin. The reference coordinate must be independently defined.



Format and Example:

1	2	3	4	5	6	7	8	9	10
CØRD2S	CID	RID	A1	A2	A3	B1	B2	B3	ABC
CØRD2S	3	17	-2.9	1.0	0.0	3.6	0.0	1.0	123
+BC	C1	C2	C3						
+23	5.2	1.0	-2.9						

Field

Contents

CID Coordinate system identification number (Integer > 0)

RID Reference to a coordinate system which is defined independently of new coordinate system (Integer ≥ 0 or blank)

A1,A2,A3
B1,B2,B3
C1,C2,C3 Coordinates of three points in coordinate system defined in field 3 (Real)

(Continued)

NASTRAN DATA DECK

CØRD2S (Cont.)

- Remarks:
1. Continuation card must be present.
 2. The three points (A1, A2, A3), (B1, B2, B3), (C1, C2, C3) must be unique and non-collinear. Noncollinearity is checked by the geometry processor.
 3. Coordinate system identification numbers on all CØRD1R, CØRD1C, CØRD1S, CØRD2R, CØRD2C, and CØRD2S cards must all be unique.
 4. An RID of zero references the basic coordinate system.
 5. The location of a grid point (P in the sketch) in this coordinate system is given by (R, Θ , Φ) where Θ and Φ are measured in degrees.
 6. The displacement coordinate directions at P are shown above by (u_r , u_θ , u_ϕ).
 7. Points on the polar axis may not have their displacement directions defined in this coordinate system since an ambiguity results.

BULK DATA DECK

Input Data Card CQDMEM

Quadrilateral Element Connection

Description: Defines a quadrilateral membrane element (QDMEM) of the structural model consisting of four overlapping TRMEM elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM	EID	PID	G1	G2	G3	G4	TH		
CQDMEM	72	13	13	14	15	16	29.2		

Field

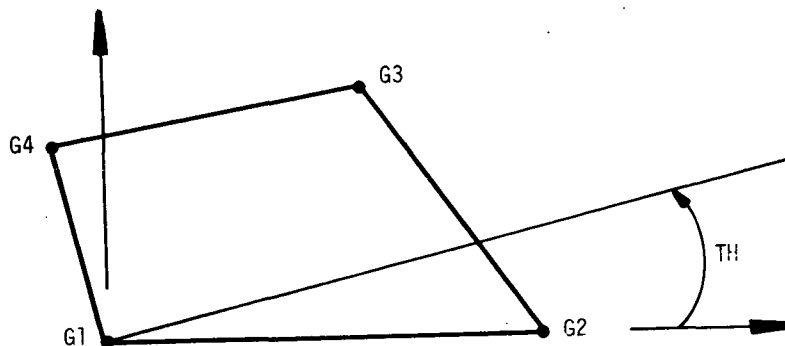
Contents

EID Element identification number (Integer > 0)

PID Identification number of a PQDMEM property card (Default is EID) (Integer > 0)

G1,G2,G3,G4 Grid point identification numbers of connection points (Integer > 0;
G1 ≠ G2 ≠ G3 ≠ G4)

TH Material property orientation angle in degrees (Real)
The sketch below gives the sign convention for TH.



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
 3. All interior angles must be less than 180°.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CQDMEM1

Isoparametric Quadrilateral Element Connection

Description: Defines an isoparametric quadrilateral membrane element (QDMEM1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM1	EID	PID	G1	G2	G3	G4	TH		
CQDMEM1	72	13	13	14	15	16	29.2		

Field

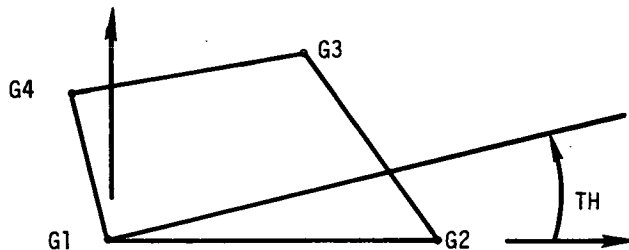
Contents

EID Element identification number (Integer > 0)

PID Identification number of a PQDMEM1 property card (Default is EID) (Integer > 0)

G1,G2,G3,G4 Grid point identification numbers of connection points (Integer > 0);
G1 ≠ G2 ≠ G3 ≠ G4)

TH Material property orientation angle in degrees (Real)
The sketch below gives the sign convention for TH



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1 through G4 must be ordered consecutively around the perimeter of the element.
 3. All interior angles must be less than 180 degrees.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CQDMEM2

Quadrilateral Element Connection

Description: Defines a quadrilateral membrane element (QDMEM2) of the structural model consisting of four nonoverlapping TRMEM elements.

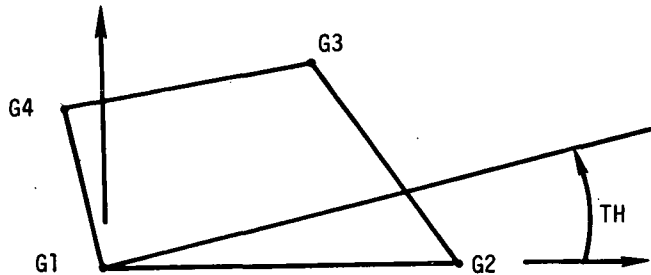
Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM2	EID	PID	G1	G2	G3	G4	TH		
CQDMEM2	72	13	13	14	15	16	29.2		

Field

Contents

EID Element identification number (Integer > 0)
 PID Identification number of a PQDMEM2 property card (Default is EID) (Integer > 0)
 G1,G2,G3,G4 Grid point identification numbers of connection points (Integer > 0;
 $G1 \neq G2 \neq G3 \neq G4$)
 TH Material property orientation angle in degrees (Real)
 The sketch below gives the sign convention for TH



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1 through G4 must be ordered consecutively around the perimeter of the element.
 3. All interior angles must be less than 180 degrees.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CQDPLT

Quadrilateral Element Connection

Description: Defines a quadrilateral bending element (QDPLT) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDPLT	EID	PID	G1	G2	G3	G4	TH		
CQDPLT	72	13	13	14	15	16	29.2		

Field

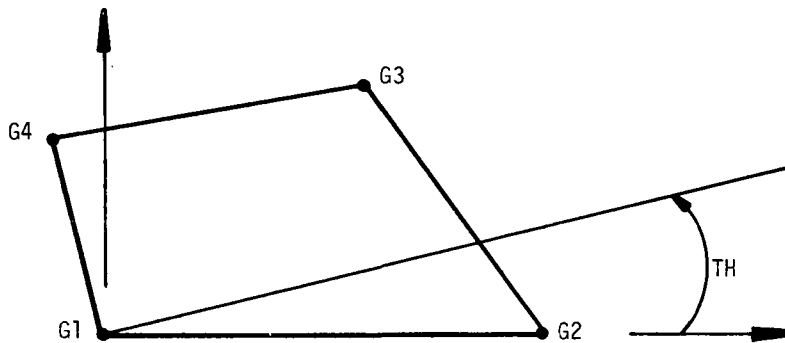
Contents

EID Element identification number (Integer > 0)

PID Identification number of a PQDPLT property card (Default is EID) (Integer > 0)

G1,G2,G3,G4 Grid point identification numbers of connection points (Integer > 0;
G1 ≠ G2 ≠ G3 ≠ G4)

TH Material property orientation angle in degrees (Real)
The sketch below gives the sign convention for TH.



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
 3. All interior angles must be less than 180°.
 4. No structural mass is generated by this element.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CQUAD1

Quadrilateral Element Connection

Description: Defines a quadrilateral membrane and bending element (QUAD1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQUAD1	EID	PID	G1	G2	G3	G4	TH		
CQUAD1	72	13	13	14	15	16	29.2		

Field

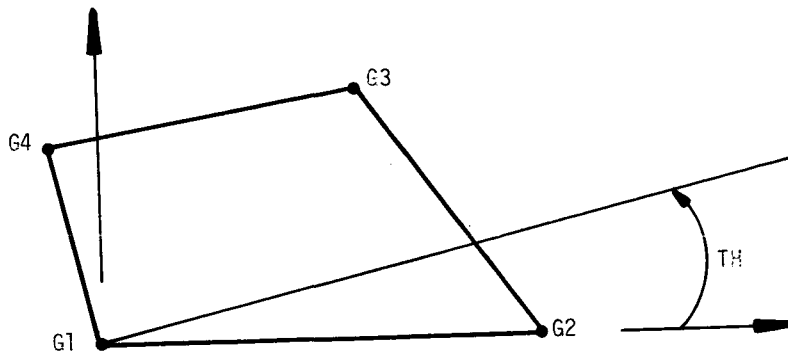
Contents

EID Element identification number (Integer > 0)

PID Identification number of a PQUAD1 property card (Default is EID) (Integer > 0)

G1,G2,G3,G4 Grid point identification numbers of connection points (Integer > 0;
G1 ≠ G2 ≠ G3 ≠ G4)

TH Material property orientation angle in degrees (Real)
The sketch below gives the sign convention for TH.



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
 3. All interior angles must be less than 180°.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CQUAD2

Quadrilateral Element Connection

Description: Defines a homogeneous quadrilateral membrane and bending element (QUAD2) of the structural model.

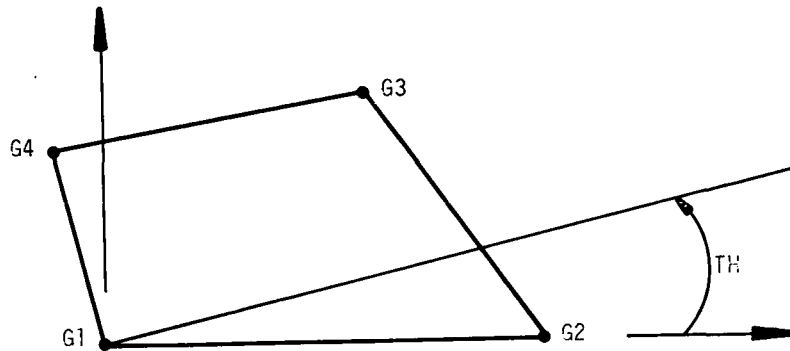
Format and Example:

1	2	3	4	5	6	7	8	9	10
CQUAD2	EID	PID	G1	G2	G3	G4	TH		
CQUAD2	72	13	13	14	15	16	29.2		

Field

Contents

EID Element identification number (Integer > 0)
 PID Identification number of a PQUAD2 property card (Default is EID) (Integer > 0)
 G1,G2,G3,G4 Grid point identification numbers of connection points (Integer > 0;
 G1 ≠ G2 ≠ G3 ≠ G4)
 TH Material property orientation angle in degrees (Real)
 The sketch below gives the sign convention for TH.



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
 3. All interior angles must be less than 180°.

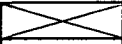
NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CRIGD1 Rigid Element Connection

Description: Defines a rigid element where all degrees of freedom of the selected dependent grid points are coupled to the degrees of freedom of the reference grid point.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRIGD1	EID		IG	G1	G2	G3	G4	G5	abc
CRIGD1	101		18	43	9	26	35	41	123
+bc	G6	G7	etc.						
+23	8	63							

Field

Contents

EID Unique element identification number (Integer > 0)

IG Identification number of the reference grid point.

G1, G2, etc. Identification numbers of the dependent grid points.

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. The reference grid point must appear before any of the dependent grid points.
 3. Any number of dependent grid points may be associated with a rigid element but only one reference grid point is allowed per rigid element.
 4. Dependent degrees of freedom defined in a rigid element may not appear on MPC, OMIT, OMIT1 or SUPORT cards.
 5. In order to use this element, a Rigid Format ALTER must be made to replace GP4 and MCE1 with ZGP4 and ZMCE1 respectively. The input and output data blocks and parameters remain the same.

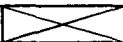
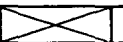
NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CRIGD2 Rigid Element Connection

Description: Defines a rigid element where selected degrees of freedom of the dependent grid points are coupled to the degrees of freedom of the reference grid point.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRIGD2	EID		IG		G1	IC1	G2	IC2	abc
CRIGD2	102		9		45	123	53	135	123
+bc	G3	IC3	etc.						
+23	27	456							

<u>Field</u>	<u>Contents</u>
EID	Unique element identification number (Integer > 0).
IG	Identification number of the reference grid point.
G1, G2, etc.	Identification numbers of the dependent grid points.
IC1, IC2, etc.	List of dependent degrees of freedom associated with the preceeding dependent grid point (any of the digits 1-6 with no imbedded blanks).

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. The reference grid point must appear before any of the dependent grid points. If any grid point of a rigid element has less than six coupled degrees of freedom, the reference grid point may not be connected to any other structural elements or rigid elements. Multiple numbering of a grid point may be used for this purpose.
 3. Any number of dependent grid points may be associated with a rigid element but only one reference grid point is allowed per rigid element.
 4. Dependent degrees of freedom defined in a rigid element may not appear on MPC, ØMIT, ØMIT1 or SUPØRT cards.
 5. In order to use this element, a Rigid Format ALTER must be made to replace GP4 and MCE1 with ZGP4 and ZMCE1 respectively. The input and output data blocks and parameters remain the same.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CRØD

Rod Element Connection

Description: Defines a tension-compression-torsion element (RØD) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRØD	EID	PID	G1	G2	EID	PID	G1	G2	
CRØD	12	13	21	23	3	12	24	5	

Field

Contents

EID Element identification number (Integer > 0)
 PID Identification number of a PRØD property card (Default is EID) (Integer > 0)
 G1, G2 Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. See CØNRØD for alternative method of rod definition.
 3. One or two RØD elements may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CSHEAR

Shear Panel Element Connection

Description: Defines a shear panel element (SHEAR) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CSHEAR	EID	PID	G1	G2	G3	G4			
CSHEAR	3	6	1	5	3	7			

Field

Contents

EID Element identification number (Integer > 0)
 PID Identification number of a PSHEAR property card (Default is EID) (Integer > 0)
 G1, G2, G3, G4 Grid point identification numbers of connection points (Integer > 0;
 G1 ≠ G2 ≠ G3 ≠ G4)

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
 3. All interior angles must be less than 180°.

NASTRAN DATA DECK


BULK DATA DECK

Input Data Card CSLØTi

Slot Element Connections

Description: Defines an element connecting $i = 3$ or $i = 4$ points which solves the wave equation in two dimensions. Used in the acoustic cavity analysis for the definition of evenly spaced radial slots.

Formats and Examples:

1	2	3	4	5	6	7	8	9	10
CSLØT3	EID	IDS1	IDS2	IDS3		RHØ	B	M	
CSLØT3	100	1	3	2		3.E-3		6	
CSLØT4	EID	IDS1	IDS2	IDS3	IDS4	RHØ	B	M	
CSLØT4	101	1	3	2	4		6.2+4	3	

Field

Contents

EID	Element identification number (Integer > 0)
IDSj	Identification number of connected GRIDS points, $j = 1, 2, \dots, J$ (Integer > 0)
RHØ	Fluid density in mass units (Real > 0.0 or "blank")
B	Fluid bulk modulus (Real \geq 0.0 or blank)
M	Number of slots in circumferential direction (Integer \geq 0, or "blank")

- Remarks:
1. This card is allowed only if an AXSLØT card is also present.
 2. The element identification number (IDF) must be unique with respect to all other fluid or structural elements.
 3. If RHØ, B, or M are blank, the corresponding values on the AXSLØT data card are used, in which case the default value must not be blank (undefined).
 4. Plot elements connecting two points at a time are generated for these elements. The CSLØT3 element generates 3 plot elements. The CSLØT4 element generates four plot elements, connecting points 1-2, 2-3, 3-4, and 4-1.
 5. If $B = 0.0$, the slot is considered to be an incompressible fluid.
 6. If $M = 0$ no matrices for CSLØTi elements are generated.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTETRA Tetrahedron Element Connection

Description: Defines a tetrahedron element (3 dimensional solid with 4 vertices and 4 triangular faces, TETRA) of the structural model.

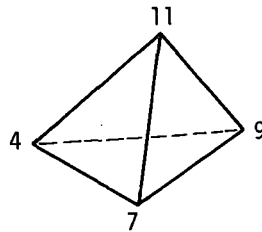
Format and Example:

1	2	3	4	5	6	7	8	9	10
CTETRA	EID	MID	G1	G2	G3	G4			
CTETRA	15	2	4	7	9	11			

Field

Contents

EID Element identification number (Integer > 0)
MID Material identification number (Integer > 0)
G1,G2,G3,G4 Grid point identification numbers of connection points (Integers > 0, G1 ≠ G2 ≠ G3 ≠ G4)



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. There is no nonstructural mass.
 3. For structural problems, material must be defined by MAT1 card.
 4. Output stresses are given in basic coordinate system.
 5. For heat transfer problems, material may be defined with either a MAT4 or MAT5 card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTØRDRG

Toroidal Ring Element Connection

Description: Defines an axisymmetric toroidal cross-section ring element (TØRDRG) of the structural model.

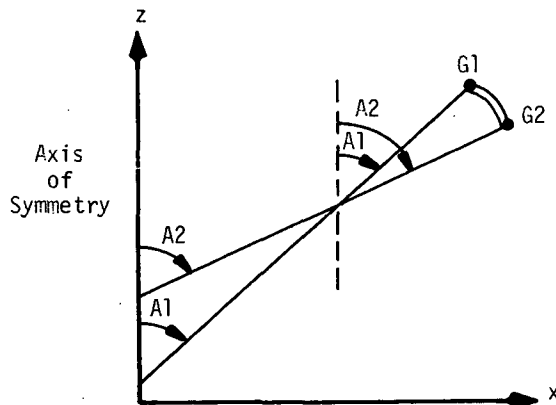
Format and Example:

1	2	3	4	5	6	7	8	9	10
CTØRDRG	EID	PID	G1	G2	A1	A2			
CTØRDRG	25	2	47	48	30.0	60.0			

Field

Contents

EID Element identification number (Integer > 0)
 PID Property identification number (Default is EID) (Integer > 0)
 G1, G2 Grid Point identification numbers of connection points (Integer > 0; G1 ≠ G2)
 A1 Angle of curvature at grid point 1 in degrees (Real; $0^\circ \leq A1 \leq 180^\circ$; $A2 \geq A1$)
 A2 Angle of curvature at grid point 2 in degrees (Real; $0^\circ \leq A2 \leq 180^\circ$; $A2 \geq A1$)



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1 and G2 must lie in the x-z plane of the basic coordinate system and to the right of the axis of symmetry (the z-axis).
 3. If $A1 = 0$, the element is assumed to be a shell cap.
 4. Only elements of zero or positive Gaussian curvature may be used.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTRAPAX Trapezoidal Ring Element Connection

Description: Defines an axisymmetric trapezoidal cross-section ring element with non-axisymmetric deformation of the structural model with reference to property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRAPAX	EID	PID	R1	R2	R3	R4	TH		
CTRAPAX	15	5	10	11	12	13	30.0		

Field

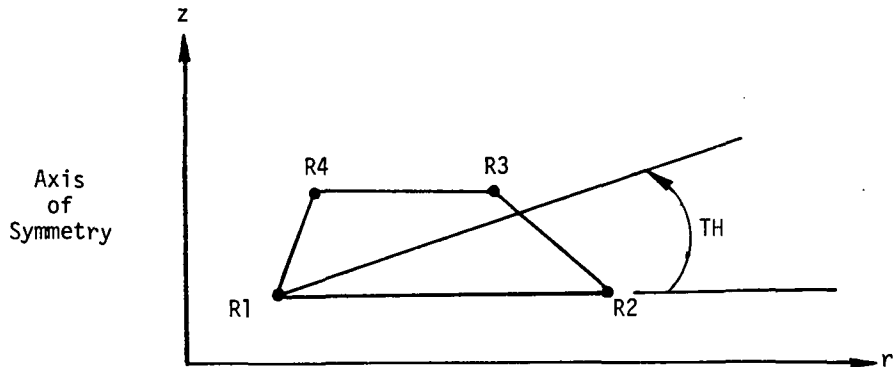
Contents

EID Element identification number (Integer > 0)

PID Identification number of a PTRAPAX card (Integer > 0)

R1,R2,R3,R4 Identification numbers of RINGAX cards (Integer > 0; $R1 \neq R2 \neq R3 \neq R4$)

TH Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



- Remarks:
1. CTRAPAX card is allowed if and only if an AXIC card is also present.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. RINGAX identification numbers R1, R2, R3 and R4 must be ordered counterclockwise around the perimeter.
 4. For a discussion of the axisymmetric ring problem, see Section 5.11 of the Theoretical Manual.
 5. The lines connecting R1 to R2 and R4 to R3 must be parallel to the r axis.
 6. This element cannot be modeled with a grid point on the axis of symmetry.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTRAPRG

Trapezoidal Ring Element Connection

Description: Defines an axisymmetric trapezoidal cross-section ring element (TRAPRG) of the structural model without reference to a property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRAPRG	EID	G1	G2	G3	G4	TH	MID		
CTRAPRG	72	13	14	15	16	29.2	13		

Field

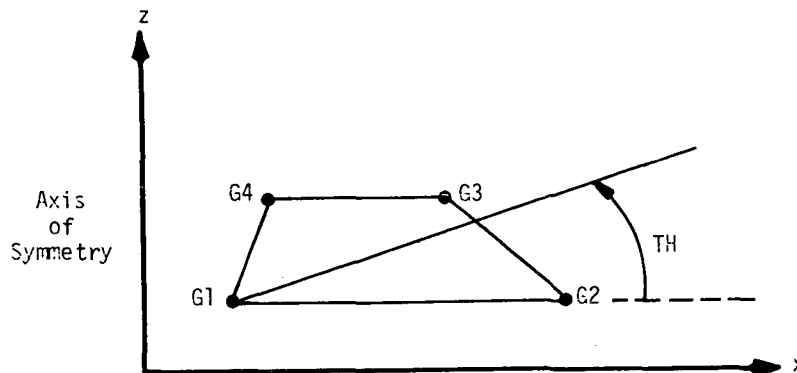
Contents

EID Element identification number (Integer > 0)

G1,G2,G3,G4 Grid point identification number of connection points (Integers > 0;
G1 ≠ G2 ≠ G3 ≠ G4)

TH Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.

MID Material property identification number (Integer > 0)



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. The four grid points must lie in the x-z plane of both the basic and any local coordinate systems and to the right of the axis of symmetry (the z-axis).
 3. Grid points G1, G2, G3 and G4 must be ordered counterclockwise around the perimeter of the element as in the above sketch.
 4. The line connecting grid points G1 and G2 and the line connecting grid points G3 and G4 must both be parallel to the x-axis.
 5. All interior angles must be less than 180°.
 6. For structural problems, the material property identification number must reference only a MAT1 or MAT3 card.
 7. For heat transfer problems, the material property identification number must reference only a MAT4 or MAT5 card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTRBSC Triangular Element Connection

Description: Defines a basic triangular bending element (TRBSC) of the structural model.

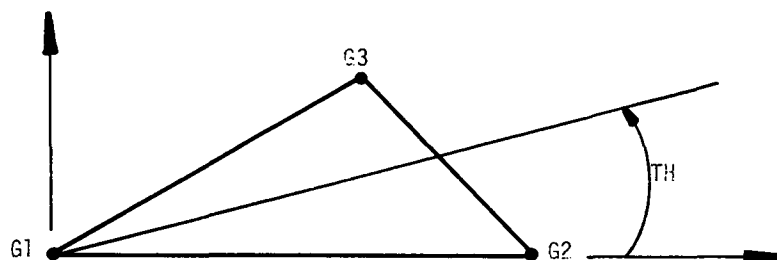
Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRBSC	EID	PID	G1	G2	G3	TH			
CTRBSC	16	2	12	1	3	16.2			

Field

Contents

EID Element identification number (Integer > 0)
 PID Identification number of a PTRBSC property card (Default is EID) (Integer > 0)
 G1,G2,G3 Grid point identification numbers of connection points (Integer > 0;
 $G1 \neq G2 \neq G3$)
 TH Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Interior angles must be less than 180°.
 3. No structural mass is generated by this element.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTRIAAX Triangular Ring Element Connection

Description: Defines an axisymmetric triangular cross-section ring element with non-axisymmetric deformation of the structural model with reference to property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIAAX	EID	PID	R1	R2	R3	TH			
CTRIAAX	20	15	42	43	52	60.0			

Field

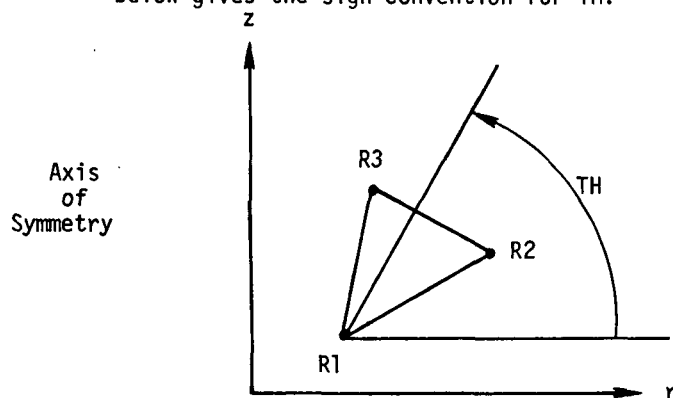
Contents

EID Element identification number (Integer > 0)

PID Identification number of a PTRIAX card (Integer > 0)

R1,R2,R3 Identification numbers of RINGAX cards (Integer > 0; $R1 \neq R2 \neq R3$)

TH Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



- Remarks:
1. CTRIAAX card is allowed if and only if an AXIC card is also present.
 2. Element identification numbers must be unique with respect to all other element identification numbers.
 3. RINGAX identification numbers R1,R2 and R3 must be ordered counterclockwise around the perimeter.
 4. For a discussion of the axisymmetric ring problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTRIARG

Triangular Ring Element Connection

Description: Defines an axisymmetric triangular cross section ring element (TRIARG) of the structural model without reference to a property card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIARG	EID	G1	G2	G3	TH	MID			
CTRIARG	16	12	13	14	29.2	17			

Field

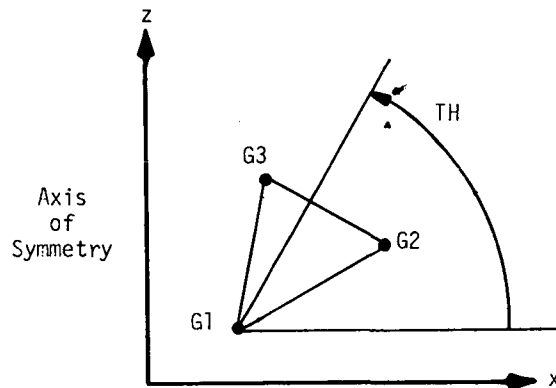
Contents

EID Element identification number (Integer > 0)

G1, G2, G3 Grid point identification numbers of connection points (Integers > 0;
G1 ≠ G2 ≠ G3)

TH Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for the TH.

MID Material identification number (Integer > 0)



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. The grid points must lie in the x-z plane of both the basic and any local coordinate systems and to the right of the axis of symmetry (the z-axis).
 3. Grid points G1, G2 and G3 must be ordered counterclockwise around the perimeter of the element as shown in the above sketch.
 4. For structural problems, the material property identification number must reference only a MAT1 or MAT3 card.
 5. For heat transfer problems, the material property identification number must reference only a MAT4 or MAT5 card.

NASTRAN DATA DECK

BULK DATA DECK

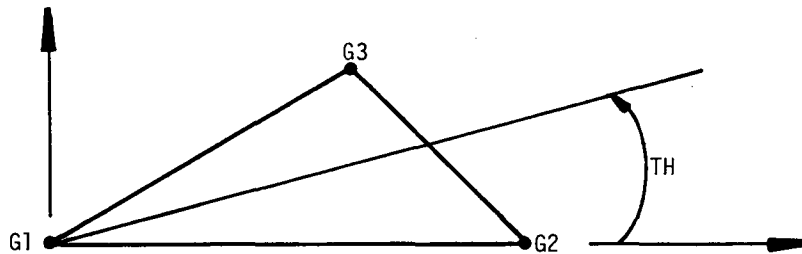
Input Data Card CTRIA1 Triangular Element Connection

Description: Defines a triangular membrane and bending element (TRIA1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIA1	EID	PID	G1	G2	G3	TH			
CTRIA1	16	2	12	1	-3	16.2			

<u>Field</u>	<u>Contents</u>
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRIA1 property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Interior angles must be less than 180°.

NASTRAN DATA DECK

BULK DATA DECK

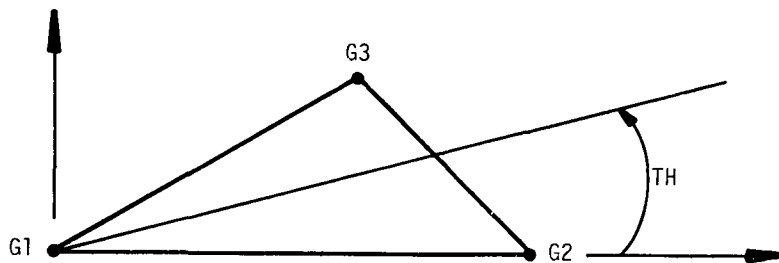
Input Data Card CTRIA2 Triangular Element Connection

Description: Defines a triangular membrane and bending element (TRIA2) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIA2	EID	PID	G1	G2	G3	TH			
CTRIA2	16	2	12	1	3	16.2			

<u>Field</u>	<u>Contents</u>
EID	Element identification number (Integer > 0)
PID	Identification number of a PTRIA2 property card (Default is EID) (Integer > 0)
G1,G2,G3	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3)
TH	Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Interior angles must be less than 180°.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTRMEM

Triangular Element Connection

Description: Defines a triangular membrane element (TRMEM) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRMEM	EID	PID	G1	G2	G3	TH			
CTRMEM	16	2	12	1	3	16.3			

Field

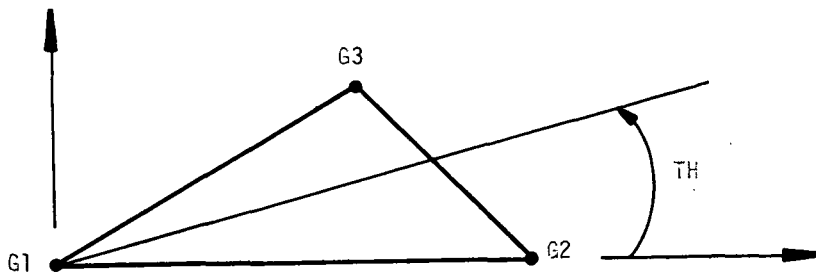
Contents

EID Element identification number (Integer > 0)

PID Identification number of a PTRMEM property card (Default is EID) (Integer > 0)

G1,G2,G3 Grid point identification numbers of connection points (Integer > 0;
G1 ≠ G2 ≠ G3)

TH Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Interior angles must be less than 180°.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTRPLT Triangular Element Connection

Description: Defines a triangular bending element (TRPLT) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRPLT	EID	PID	G1	G2	G3	TH			
CTRPLT	16	2	12	1	3	16.2			

Field

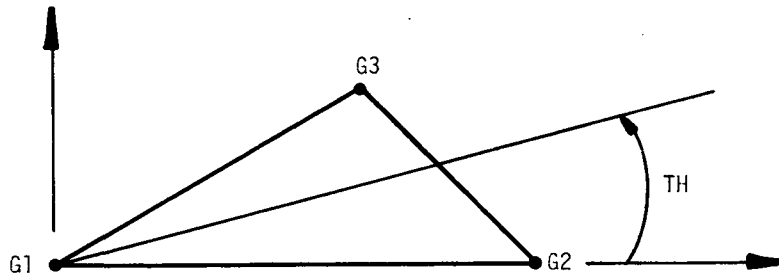
Contents

EID Element identification number (Integer > 0)

PID Identification number of a PTRPLT property card (Default is EID) (Integer > 0)

G1,G2,G3 Grid point identification numbers of connection points (Integer > 0;
G1 ≠ G2 ≠ G3)

TH Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Interior angles must be less than 180°.
 3. No structural mass is generated by this element.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTUBE Tube Element Connection

Description: Defines a tension-compression-torsion element (TUBE) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTUBE	EID	PID	G1	G2	EID	PID	G1	G2	
CTUBE	12	13	21	23	3	12	24	5	

<u>Field</u>	<u>Contents</u>
EID	Element identification number (Integer > 0)
PID	Identification number of a PTUBE property card (Default is EID) (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. One or two TUBE elements may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CTWIST Twist Panel Element Connection

Description: Defines a twist panel element (TWIST) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTWIST	EID	PID	G1	G2	G3	G4			
CTWIST	2	6	1	5	3	7			

Field

Contents

EID Element identification number (Integer > 0)
 PID Identification number of a PTWIST property card (Default is EID) (Integer > 0)
 G1,G2,G3,G4 Grid point identification numbers of connection points (Integer > 0;
 G1 ≠ G2 ≠ G3 ≠ G4)

- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. Grid points G1 thru G4 must be ordered consecutively around the perimeter of the element.
 3. All interior angles must be less than 180°.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CVISC Viscous Damper Connection

Description: Defines a viscous damper element (VISC) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CVISC	EID	PID	G1	G2	EID	PID	G1	G2	
CVISC	21	6327	29	31	22	6527	35	33	

<u>Field</u>	<u>Contents</u>
EID	Element identification number (Integer > 0)
PID	Identification number of PVISC property card (Default is EID) (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. One or two VISC elements may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CWEDGE

Wedge Element Connection

Description: Defines a wedge element (3 dimensional solid, with three quadrilateral faces and two opposing triangular faces, WEDGE) of the structural model.

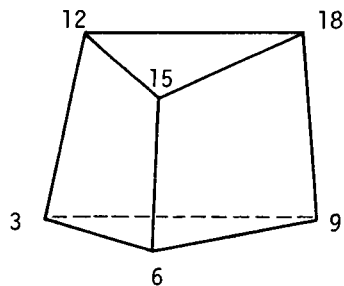
Format and Example:

1	2	3	4	5	6	7	8	9	10
CWEDGE	EID	MID	G1	G2	G3	G4	G5	G6	
CWEDGE	15	2	3	6	9	12	15	18	

Field

Contents

EID Element identification number (Integer > 0)
MID Material identification number (Integer > 0)
G1,...,G6 Grid point identification numbers of connection points (Integers > 0,
 G1 ≠ G2 ≠ ... ≠ G6)



- Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
 2. The order of the grid points is: G1, G2, G3 on one triangular face, G4, G5, G6 at the other triangular face. G1, G4 on a common edge, G2, G5 on a common edge.
 3. The quadrilateral faces must be nearly planar.
 4. There is no nonstructural mass.
 5. For structural problems, material must be defined by MAT1 card.
 6. Output stresses are given in the basic coordinate system.
 7. For heat transfer problems, material may be defined with either a MAT4 or MAT5 card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card CYJØIN

Description: Defines the boundary points of a segment for cyclic symmetry structural molds.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CYJØIN	SIDE	C	G1	G2	G3	G4	G5	G6	abc
CYJØIN	1		7	9	16	25	33	64	ABC

+bc	G7	G8	G9	-etc.-					
+BC	72								

Alternate Form

CYJØIN	SIDE	C	GID1	"THRU"	GID2				
CYJØIN	2	S	6	THRU	32				

Field

Contents

SIDE	Side identification (Integer 1 or 2)
C	Coordinate System (BCD value R,C or S or blank)
Gi,GIDi	Grid or scalar point identification numbers (Integer > 0)

- Remarks:
1. CYJØIN bulk data cards are only used for cyclic symmetry problems. A parameter (CTYPE) must specify rotational or dihedral symmetry.
 2. For rotational symmetry problems there must be one logical card for side 1 and one for side 2. The two lists specify grid points to be connected, hence both lists must have the same length.
 3. For dihedral symmetry problems, side 1 refers to the boundary between segments and side 2 refers to the middle of a segment. A coordinate system must be referenced in field 3, where R = rectangular C = cylindrical and S = spherical.
 4. All components of displacement at boundary points are connected to adjacent segments, except those constrained by SPC, MPC or ØMIT.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card DAREA

Dynamic Load Scale Factor

Description: This card is used in conjunction with the RLØAD1, RLØAD2, TLØAD1, and TLØAD2 data cards and defines the point where the dynamic load is to be applied with the scale (area) factor A.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DAREA	SID	P	C	A	P	C	A		
DAREA	3	6	2	8.2	15	1	10.1		

Field

Contents

SID Identification number of DAREA set (Integer > 0)
P Grid or scalar point identification number (Integer > 0)
C Component number (1-6 for grid point; blank or 0 for scalar point)
A Scale (area) factor A for the designated coordinate (Real)

Remarks: One or two scale factors may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card DEFØRM

Element Deformation

Description: Defines enforced axial deformation for one-dimensional elements for use in statics problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DEFØRM	SID	EID	D	EID	D	EID	D		
DEFØRM	1	535	.05	536	-.10				

Field

Contents

SID Deformation set identification number (Integer > 0)
 EID Element number (Integer > 0)
 D Deformation (+ = elongation) (Real)

- Remarks:
1. The referenced element must be one-dimensional (i.e., a RØD (including CØNRØD), TUBE or BAR).
 2. Deformation sets must be selected in the Case Control Deck (DEFØRM=SID) to be used by NASTRAN.
 3. From one to three enforced element deformations may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card DELAY

Dynamic Load Time Delay

Description: This card is used in conjunction with the RLØAD1, RLØAD2, TLØAD1 and TLØAD2 data cards and defines the time delay term τ in the equations of the loading function.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DELAY	SID	P	C	T	P	C	T		
DELAY	5	21	6	4.25	7	6	8.1		

Field

Contents

SID Identification number of DELAY set (Integer > 0)
P Grid or scalar point identification number (Integer > 0)
C Component number (1-6 for grid point, blank or 0 for scalar point)
T Time delay τ for designated coordinate (Real)

Remarks: One or two dynamic load time delays may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card DLØAD

Dynamic Load Combination (Superposition)

Description: Defines a dynamic loading condition for frequency response or transient response problems as a linear combination of load sets defined via RLØAD1 or RLØAD2 cards (for frequency response) or TLØAD1 or TLØAD2 cards (for transient response).

Format and Example:

1	2	3	4	5	6	7	8	9	10
DLØAD	SID	S	S1	L1	S2	L2	S3	L3	+abc
DLØAD	17	1.0	2.0	6	-2.0	7	2.0	8	+A
+abc	S4	L4		-etc.-					
+A	-2.0	9							

-etc.-

Field

Contents

SID	Load set identification number (Integer > 0)
S	Scale Factor (Real)
Si	Scale Factors (Real)
Li	Load set identification numbers defined via card types enumerated above (Integer > 0)

Remarks: 1. The load vector being defined by this card is given by

$$\{P\} = S \sum_i S_i \{P_{Li}\}.$$

2. The Li must be unique.
3. SID must be unique from all Li.
4. Nonlinear transient loads may not be included; they are selected separately in the Case Control Deck.
5. Linear load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
6. A DLØAD card may not reference a set identification number defined by another DLØAD card.
7. TLØAD1 and TLØAD2 loads may be combined only thru the use of the DLØAD card.
8. RLØAD1 and RLØAD2 loads may be combined only thru the use of the DLØAD card.
9. SID must be unique for all TLØAD1, TLØAD2, RLØAD1, and RLØAD2 cards.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card DMI

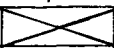
Direct Matrix Input

Description: Used to define matrix data blocks directly. Generates a matrix of the form

$$[A] = \begin{bmatrix} A_{11} & A_{12} & \dots & A_{1n} \\ A_{21} & A_{22} & \dots & A_{2n} \\ \vdots & \vdots & & \vdots \\ A_{m1} & \dots & \dots & A_{mn} \end{bmatrix}$$

where the elements A_{ij} may be real or complex single-precision or double precision numbers.

Formats and Example: (The first logical card is a header card.)

1	2	3	4	5	6	7	8	9	10
DMI	NAME	"0"	FØRM	TIN	TØUT		M	N	
DMI	QQQ	0	2	3	3		4	2	
DMI	NAME	J	I1	A(I1,J)	A(I1+1,J)		etc.	I2	+abc
DMI	QQQ	1	1	1.0	2.0	3.0	4.0	3	+1
+abc	A(I2,J)		etc.						
+1	5.0	6.0							
DMI	QQQ	2	2	6.0	7.0	4	8.0	9.0	

(etc. for each nonnull column)

Field

Contents

NAME	Any NASTRAN BCD value (1-8 alphanumeric characters, the first of which must be alphabetic) which will be used in the DMAP sequence to reference the data block
FØRM	1 Square matrix (not symmetric) 2 General rectangular matrix 6 Symmetric matrix
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 2 Real, double-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element) 4 Complex, double-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 2 Real, double-precision 3 Complex, single-precision 4 Complex, double-precision
M	Number of rows in A (Integer > 0)
N	Number of columns in A (Integer > 0)
J	Column number of A (Integer > 0)
I1,I2,etc.	Row number of A (Integer > 0)
A(Ix,J)	Element of A (See TIN) (Real)

(Continued)

NASTRAN DATA DECK

DMI (Cont.)

- Remarks:
1. The user must write a DMAP (or make alterations to a rigid format) in order to use the DMI feature since he is defining a data block. All of the rules governing the use of data blocks in DMAP sequences apply. In the example shown above, the data block QQQ is defined to be the complex, single-precision rectangular 4x2 matrix

$$[QQQ] = \begin{bmatrix} (1.0, 2.0) & (0.0, 0.0) \\ (3.0, 4.0) & (6.0, 7.0) \\ (5.0, 6.0) & (0.0, 0.0) \\ (0.0, 0.0) & (8.0, 9.0) \end{bmatrix}$$

The DMAP data block NAME (QQQ in the example) will appear in the initial FIAT and the data block will initially appear on the Data Pool File (P00L).

2. A limit to the number of DMI's which may be defined is set by the size of the Data Pool Dictionary. The total number of DMI's may not exceed this size.
3. There are a number of reserved words which may not be used for DMI names. Among these are P00L, NPTP, 0PTP, UMF, NUMF, PLT1, PLT2, INPT, GE0M1, GE0M2, GE0M3, GE0M4, GE0M5, EDT, MPT, EPT, DIT, DYNAMICS, IFPFILE, AXIC, F0RCE, MATP00L, PCDB, XYCDB, CASECC, any DTI names, and SCRATCH1 thru SCRATCH9.
4. Field 3 of the header card must contain an integer 0.
5. For symmetric matrices, the entire matrix must be input.
6. Only nonzero terms need be entered.
7. A blank field on this card is not equivalent to a zero. If zero input is desired, the appropriate type zero must be punched (i.e., 0.0 or 0.0D0).
8. Complex input must have both the real and imaginary parts punched if either part is nonzero.
9. A new column requires a new card be started.

BULK DATA DECK

Input Data Card DMIAX

Direct Axisymmetric Matrix Input

Description: Defines axisymmetric (fluid or structure) related direct input matrix terms.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DMIAX	NAME	"0"	IFØ	TIN	TØUT				
DMIAX	B2PP	0	1	3	4				
DMIAX	NAME	GJ	CJ	NJ					+abc
DMIAX	B2PP	32							+BG27
+abc	GI	CI	NI	X _{ij}	Y _{ij}				+def
+BG27	1027	3		4.35+6	2.27+3				

-etc. for each column and row containing nonzero terms-

Field

Contents

NAME	BCD name of matrix (one to eight alphanumeric characters the first of which is alphabetic)
IFØ	<div> <div> 1 Square matrix 2 General rectangular matrix 6 Symmetric matrix </div> <div> } Identification of Matrix Form </div> </div>
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double precision 4 Complex, double-precision
GJ, GI	Grid, scalar, RINGFL fluid point, PRESPT pressure point, FREEPT free surface displacement, or extra point identification number (Integer > 0)
CJ, CI	Component number for GJ or GI grid point (0 ≤ Integer ≤ 6; Blank or zero if GJ or GI is a scalar, fluid, or extra point)
NJ, NI	Harmonic number of RINGFL point. Must be blank if a point type other than RINGFL is used. Negative number implies the "sine" series, positive implies the "cosine" series. (Integer)
X _{ij} , Y _{ij}	Real and Imaginary parts of matrix element; row (GI, CI, NI) column (GJ,CJ,NJ)

(Continued)

NASTRAN DATA DECK

DMIAX (Cont.)

- Remarks:
1. This card is allowed only if an AXIF card is also present.
 2. Matrices defined on this card may be used in dynamics by selection in the Case Control Deck by K2PP=NAME, B2PP=NAME, or M2PP=NAME for $[K_{pp}^2]$, $[B_{pp}^2]$, or $[M_{pp}^2]$ respectively.
 3. In addition to the header card containing IF0, TIN and TOUT, a logical card consisting of two or more physical cards is needed for each nonnull column of the matrix.
 4. If TIN = 1, Y_{ij} must be blank.
 5. Field 3 of the header card must contain an integer 0.
 6. For symmetric matrices, the entire matrix must be input.
 7. Only nonzero terms need be entered.

BULK DATA DECK

Input Data Card DMIG

Direct Matrix Input at Grid Points

Description: Defines structure-related direct input matrices.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DMIG	NAME	"0"	IFØ	TIN	TØUT				
DMIG	STIF	0	1	3	4				
DMIG	NAME	GJ	CJ		GI	CI	X _{ij}	Y _{ij}	Xabc
DMIG	STIF	27	1		2	3	3.+5	3.+3	EKG1
+abc	GI	CI	X _{ij}	Y _{ij}	GI	CI	X _{ij}	Y _{ij}	Xcef
+KGI	2	4	2.5+10	0.	50		1.0	0.	

etc. for each column containing nonzero terms

Field	Contents
NAME	BCD name of matrix (one to eight alphanumeric characters the first of which is alphabetic)
IFØ	1 Square matrix 2 General rectangular matrix 6 Symmetric matrix
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double-precision 4 Complex, double-precision
GJ, GI	Grid or scalar or extra point identification number (Integer > 0)
CJ, CI	Component number for GJ a grid point (0 < CJ ≤ 6); blank or zero for GJ a scalar or extra point
X _{ij} , Y _{ij}	Real and imaginary parts of matrix element

- Remarks:
1. Matrices defined on this card may be used in dynamics by selection in the Case Control Deck by K2PP=NAME, B2PP=NAME, or M2PP=NAME for $[K_{pp}^2]$, $[B_{pp}^2]$, or $[M_{pp}^2]$, respectively.
 2. In addition to the header card containing IFØ, TIN and TØUT, a logical card consisting of one or more physical cards is needed for each nonnull column of the matrix.
 3. If TIN = 1, Y_{ij} must be blank.
 4. Field 3 of the header card must contain an integer 0.
 5. For symmetric matrices, the entire matrix must be input.
 6. Only nonzero terms need be entered.
 7. The matrix names must be unique among all DMIG's.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card DPHASE

Dynamic Load Phase Lead

Description: This card is used in conjunction with the RLØAD1 and RLØAD2 data cards to define the phase lead term θ in the equation of the loading function.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DPHASE	SID	P	C	TH	P	C	TH		
DPHASE	4	21	6	2.1	8	6	7.2		

Field

Contents

SID Identification number of DPHASE set (Integer > 0)
P Grid or scalar point identification number (Integer > 0)
C Component number (1-6 for grid point, 0 or blank for scalar point)
TH Phase lead θ (in degrees) for designated coordinate (Real)

Remarks: One or two dynamic load phase lead terms may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card DSFACT Differential Stiffness Factors

Description: Used to define scale factors for applied loads and stiffness matrices in a Differential Stiffness Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DSFACT	SID	B1	B2	B3	B4	B5	B6	B7	abc
DSFACT	97	-1.0	-2.0	-4.0					
+bc	B8	B9	-etc.-						

-etc.-

<u>Field</u>	<u>Contents</u>
SID	Set identification number (Unique Integer > 0)
Bi	Scale factor (Real)

- Remarks:
1. Load sets must be selected in the Case Control Deck (DSC0=SID) to be used by NASTRAN.
 2. All fields following the last entry must be blank.
 3. An error is detected if any continuation cards follow the last entry.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card DTI

Direct Table Input

Description: Used to define table data blocks directly.

Format and Example: (The first logical card is a header card)

1	2	3	4	5	6	7	8	9	10
DTI	NAME	"0"	T1	T2	T3	T4	T5	T6	+00
DTI	XXX	0	3	4	4096	32768	1	0	
+00	V	V		-etc.-	ENDREC				+01
-etc.-									
DTI	NAME	IREC	V	V	V	V	V	V	+11
DTI	XXX	1	2.0	-6	ABC	6.000	-1	2	+11
+11	V	V	V	V	-etc.-	ENDREC			+12
+11	4	-6.2	2.9	1	DEF	-1	ENDREC		
-etc.-									

Field	Contents
NAME	Any NASTRAN BCD value (1-8 alphanumeric characters, the first of which must be alphabetic) which will be used in the DMAP sequence to reference the data block
Ti	Trailer values (65535 ≥ Integer ≥ 0)
IREC	Record Number (sequential integer beginning with 1)
V	Value (blank, integer, real, BCD (except "ENDREC"), double precision)
ENDREC	The BCD value ENDREC which flags the end of the string of values that constitute logical record IREC

Remarks:

1. Records may be made as long as desired via continuation cards.
2. Values may be of any type (blank, integer, real, BCD, double precision) with the exception that a BCD value may not be "ENDREC".
3. All fields following ENDREC must be blank.
4. The user must write a DMAP (or make alterations to a rigid format) in order to use the DTI feature since he is defining a data block. All of the rules governing the use of data blocks in DMAP sequences apply.
5. The DMAP data block NAME (XXX in the example) will appear in the initial FIAT and the data block will initially appear on the P00L.
6. If trailer is not specified, T1 = number of records, T2 thru T6 = 0.
7. In addition to the header card, there must be one logical card for each record in the table.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card EIGB

Buckling Analysis Data

Description: Defines data needed to perform buckling analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGB	SID	METHØD	L1	L2	NEP	NDP	NDN	E	+abc
EIGB	13	DET	0.1	2.5	2	1	1	0.0	ABC
+abc	NØRM	G	C						
+BC	MAX								

Field

Contents

SID	Set identification number (Unique integer > 0)
METHØD	Method of eigenvalue extraction, one of the BCD values "INV", "DET", "UINV", or "UDET"
	INV - Inverse power method, symmetric matrix operations
	DET - Determinant method, symmetric matrix operations
	UINV - Inverse power method, unsymmetric matrix operations
	UDET - Determinant method, unsymmetric matrix operations
L1,L2	Eigenvalue range of interest (Real; $L1 < L2 > 0.0$)
NEP	Estimate of number of roots in positive range (Integer > 0)
NDP, NDN	Desired number of positive and negative roots (Default = 3 NEP) (Integer > 0)
E	Convergence criteria (optional) (Real ≥ 0.0)
NØRM	Method for normalizing eigenvectors, one of the BCD values "MAX" or "PØINT"
	MAX - Normalize to unit value of the largest component in the analysis set
	PØINT - Normalize to unit value of the component defined in fields 3 and 4 defaults to "MAX" if defined component is zero.
G	Grid or scalar point identification number (Integer > 0) (Required if and only if NØRM = "PØINT")
C	Component number (One of the integers 1-6) (Required if and only if NØRM = "PØINT" and G is a geometric grid point)

Remarks:

1. Buckling analysis root extraction data sets must be selected in the Case Control Deck (METHØD = SID) to be used by NASTRAN.

NASTRAN DATA DECK

EIGB (Cont.)

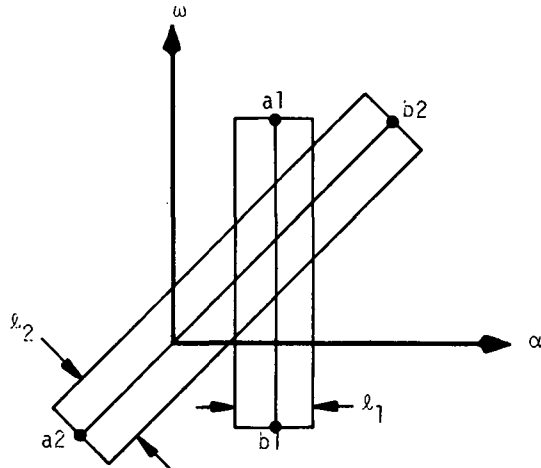
2. The quantities L1 and L2 are dimensionless and specify a range in which the eigenvalues are to be found. An eigenvalue is a factor by which the prebuckling state of stress (first subcase) is multiplied to produce buckling.
3. The continuation card is required.
4. See Sections 10.3.6 and 10.4.2.2 of the Theoretical Manual for a discussion of convergence criteria.
5. If METHØD = DET, L1 must be greater than or equal to 0.0.
6. If NØRM = MAX, components that are not in the analysis set may have values larger than unity.
7. If NØRM = PØINT, the selected component must be in the analysis set.

BULK DATA DECK

Input Data Card EIGC

Complex Eigenvalue Extraction Data

Description: Defines data needed to perform complex eigenvalue analysis.



Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGC	SID	METHØD	NØRM	G	C	E			+abc
EIGC	14	DET	PØINT	27		1.-8			ABC
+abc	α_{a1}	ω_{a1}	α_{b1}	ω_{b1}	l_1	N_{e1}	N_{d1}		+def
+BC	2.0	5.6	2.0	-3.4	2.0	4	4		DEF
+def	α_{a2}	ω_{a2}	α_{b2}	ω_{b2}	l_2	N_{e2}	N_{d2}		
+EF	-5.5	-5.5	5.6	5.6	1.5	6	3		

(etc.)

Field

Contents

SID

Set identification number (Unique integer > 0)

METHØD

Method of complex eigenvalue extraction, one of the BCD values, "INV" "DET" or "HESS"

INV - Inverse power method

DET - Determinant method

HESS - Upper Hessenburg method

NASTRAN DATA DECK

EICG (Cont.)

NØRM	Method for normalizing eigenvectors, one of the BCD values "MAX" or "PØINT"
	MAX - Normalize to a unit value for the real part and a zero value for the imaginary part, the component having the largest magnitude
	PØINT - Normalize to a unit value for the real part and a zero value for the imaginary part the component defined in fields 5 and 6 - defaults to "MAX" if the magnitude of the defined component is zero.
G	Grid or scalar point identification number (Required if and only if NØRM=PØINT) (Integer > 0)
C	Component number (Required if and only if NØRM="PØINT" and G is a geometric grid point) ($0 \leq \text{integer} \leq 6$)
E	Convergence criterion (optional) (Real ≥ 0.0)
$\begin{pmatrix} \alpha_{aj}, \omega_{aj} \\ \alpha_{bj}, \omega_{bj} \end{pmatrix}$	Two complex points defining a line in the complex plane (Real)
ℓ_j	Width of region in complex plane (Real > 0.0)
N_{ej}	Estimated number of roots in each region (Integer > 0)
N_{dj}	Desired number of roots in each region (Default is $3N_{ej}$) (Integer > 0)

- Remarks:
- Each continuation card defines a rectangular search region. Any number of regions may be used and they may overlap. Roots in overlapping regions will not be extracted more than once.
 - Complex eigenvalue extraction data sets must be selected in the Case Control Deck (CMETHØD=SID) to be used by NASTRAN.
 - The units of α , ω and ℓ are radians per unit time.
 - At least one continuation card is required.
 - For the determinant method with no damping matrix, complex conjugates of the roots found are not printed.
 - See Section 10.4.4.5 of the Theoretical Manual for a discussion of convergence criteria.
 - For the Upper Hessenberg method, N_{dj} controls the number of vectors computed. Only one continuation card is considered and the (α, ω) pairs, along with the parameters ℓ_j and N_{ej} , are ignored. Insufficient storage for HESS will cause the program to switch to INV.

BULK DATA DECK

Input Data Card EIGP

Poles in Complex Plane

Description: Defines poles that are used in complex eigenvalue extraction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGP	SID	α	ω	M	α	ω	M		
EIGP	15	-5.2	0.0	2	6.3	5.5	3		

Field

Contents

SID Set identification number (Integer > 0)

(α, ω) Coordinates of point in complex plane (Real)

M Multiplicity of complex root at pole defined by (α, ω) (Integer > 0)

Remarks:

1. Defines poles in complex plane that are used with associated EIGC card having same set number.
2. The units of α, ω are radians per unit time.
3. Poles are used only in the Determinant Method.
4. One or two poles may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card EIGR

Real Eigenvalue Extraction Data

Description: Defines data needed to perform real eigenvalue analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGR	SID	METHØD	F1	F2	NE	ND	NZ	E	+abc
EIGR	13	DET	1.9	15.6	10	12	0	1.-3	ABC
+abc	NØRM	G	C						
+BC	PØINT	32	4						

Field

SID	Set identification number (Unique integer > 0)
METHØD	Method of eigenvalue extraction, one of the BCD values "INV", "DET", "GIV", "UINV", or "UDET". INV - Inverse power method, symmetric matrix operations. DET - Determinant method, symmetric matrix operations. GIV - Givens method of tridiagonalization. UINV - Inverse power method, unsymmetric matrix operations. UDET - Determinant method, unsymmetric matrix operations.
F1,F2	Frequency range of interest (Required for METHØD = "DET", "INV", "UDET", or "UINV") (Real ≥ 0.0 ; $F1 < F2$). Frequency range over which eigenvectors are desired for METHØD = "GIV". The frequency range is ignored if ND > 0, in which case the eigenvectors for the first ND positive roots are found. (Real, $F1 < F2$).
NE	Estimate of number of roots in range (Required for METHØD = "DET", "INV", "UDET", or "UINV") (Integer > 0)
ND	Desired number of roots for METHØD = "DET", "INV", "UDET", or "UINV" (Default is 3 NE) (Integer > 0). Desired number of eigenvectors for METHØD = "GIV" (Default is zero) (Integer ≥ 0)
NZ	Number of free body modes (Optional - used only if METHØD = "DET" or "UDET") (Integer ≥ 0)
E	Mass orthogonality test parameter (Default is 0.0 which means no test will be made) (Real ≥ 0.0)
NØRM	Method for normalizing eigenvectors, one of the BCD values "MASS", "MAX" or "PØINT" MASS - Normalize to unit value of the generalized mass MAX - Normalize to unit value of the largest component in the analysis set PØINT - Normalize to unit value of the component defined in fields 3 and 4 - defaults to "MAX" if defined component is zero

NASTRAN DATA DECK

EIGR (Cont.)

- G Grid or scalar point identification number (Required if and only if NØRM="PØINT")
 (Integer ≥ 0)
- C Component number (One of the integers 1-6) (Required if and only if NØRM="PØINT"
 and G is a geometric grid point)

Remarks:

1. Real eigenvalue extraction data sets must be selected in the Case Control Deck (METHOD = SID) to be used by NASTRAN.
2. The units of F1 and F2 are cycles per unit time.
3. The continuation card is required.
4. If METHOD = "GIV", all eigenvalues are found.
5. If METHOD = "GIV", the mass matrix for the analysis set must be positive definite. This means that all degrees of freedom, including rotations, must have mass properties. ØMIT cards may be used to remove massless degrees of freedom.
6. A nonzero value of E in field 9 also modifies the convergence criteria. See Sections 10.3.6 and 10.4.2.2 of the Theoretical Manual for a discussion of convergence criteria.
7. If NØRM = MAX, components that are not in the analysis set may have values larger than unity.
8. If NØRM = PØINT, the selected component must be in the analysis set.
9. If METHOD = "GIV" and rigid body modes are present, F1 should be set to zero if the rigid body eigenvectors are desired.
10. The desired number of roots (ND) includes all roots previously found, such as rigid body modes determined with the use of the SUPØRT card, or the number of roots found on the previous run when restarting and APPENDING the eigenvector file.

BULK DATA DECK

Input Data Card EPØINT Extra Point

Description: Defines extra points of the structural model for use in dynamics problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EPØINT	ID	ID	ID	ID	ID	ID	ID	ID	
EPØINT	3	18	1	4	16	2			

Alternate Form

EPØINT	ID1	"THRU"	ID2						
EPØINT	17	THRU	43						

Field

Contents

ID, ID1, ID2 Extra point identification number (Integer > 0; ID1 < ID2)

- Remarks:
1. All extra point identification numbers must be unique with respect to all other structural, scalar, and fluid points.
 2. This card is used to define coordinates used in transfer function definitions (see TF card).
 3. If the alternate form is used, extra points ID1 thru ID2 are defined.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FLFACT Aerodynamic Physical Data

Description: Used to specify densities, Mach numbers, and reduced frequencies for flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLFACT	SID	F1	F2	F3	F4	F5	F6	F7	ABC
FLFACT	97	.3	.7	3.5					
+BC	F8	F9	--etc.--						

Field

Contents

SID Set identification number (unique integer > 0).

Fi Aerodynamic factor (real).

Remarks:

1. These factors must be selected by a FLUTTER data card to be used by NASTRAN.
2. Imbedded blank fields are forbidden.
3. Parameters must be listed in the order in which they are to be used within the looping of flutter analysis.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FLSYM Axisymmetric Symmetry Control

Description: Defines the relationship between the axisymmetric fluid and a structural boundary having symmetric constraints. The purpose is to allow fluid boundary matrices to conform to structural symmetry definitions.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLSYM	M	S1	S2						
FLSYM	12	S	A						

Field

Contents

M Number of symmetric sections of structural boundary around circumference of fluid being modeled by the set of structural elements (Integer ≥ 2 , even)

S1, S2 Description of boundary constraints used on structure at first and second planes of symmetry. (BCD: "S" \Rightarrow symmetric, "A" \Rightarrow antisymmetric)

- Remarks:
1. This card is allowed only if an AXIF card is also present.
 2. Only one (1) FLSYM card is allowed.
 3. The card is not required if no planes of symmetry are involved.
 4. First plane of symmetry is assumed to be at $\phi = 0$. Second plane of symmetry is assumed to be at $\phi = 360^\circ/M$.
 5. Symmetric and antisymmetric constraints for the structure must, in addition, be provided by the user.
 6. The solution is performed for those harmonic indices listed on the AXIF card that are compatible with the symmetry conditions.

Example: If a quarter section of structure is used to model the boundary, $M = 4$. If the boundary constraints are S-S, the compatible cosine harmonics are: 0, 2, 4, etc. If S-A is used the compatible cosine harmonics are 1, 3, 5, ..., etc.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FLUTTER Aerodynamic Flutter Data

Description: Defines data needed to perform flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLUTTER	SID	METHØD	DENS	MACH	RFREQ	IMETH	NVALUE		
FLUTTER	19	K	119	219	319	S	5		

<u>Field</u>	<u>Contents</u>
SID	Set identification number (unique integer > 0).
METHØD	Flutter analysis method, "K" for k-method (BCD).
DENS	Identification number of an FLFACT data card specifying density ratios to be used in flutter analysis (integer ≥ 0).
MACH	Identification number of an FLFACT data card specifying Mach numbers (m) to be used in flutter analysis (integer ≥ 0).
RFREQ	Identification number of an FLFACT data card specifying reduced frequencies (k) to be used in flutter analysis (integer ≥ 0).
IMETH	Choice of interpolation method for matrix interpolation (BCD: L = linear, S = surface, default is S).
NVALUE	Number of eigenvalues for output and plots (integer > 0).

Remarks:

1. The FLUTTER data card must be selected in Case Control Deck (FMETHØD = SID).
2. The density is given by $\rho \cdot RHØREF$ where ρ is the density ratio given on the FLFACT data card and RHØREF is the reference density given on the AERØ data card.
3. The reduced frequency is given by $k = (REFC \cdot \omega / 2 \cdot V)$, where REFC is given on the AERØ data card, ω is the circular frequency and V is the velocity.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FØRCE Static Load

Description: Defines a static load at a grid point by specifying a vector.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCE	SID	G	CID	F	N1	N2	N3		
FØRCE	2	5	6	2.9	0.0	1.0	0.0		

<u>Field</u>	<u>Contents</u>
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
CID	Coordinate system identification number (Integer ≥ 0)
F	Scale factor (Real)
N1,N2,N3	Components of Vector measured in coordinate system defined by CID (Real; $N1^2 + N2^2 + N3^2 > 0.0$)

Remarks: 1. The static load applied to grid point G is given by

$$\vec{f} = F \vec{N}$$

where \vec{N} is the vector defined in fields 6, 7 and 8.

2. Load sets must be selected in the Case Control Deck (LOAD=SID) to be used by NASTRAN.
3. A CID of zero references the basic coordinate system.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FØRCE1

Static Load

Description: Used to define a static load by specification of a value and two grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCE1	SID	G	F	G1	G2				
FØRCE1	6	13	-2.93	16	13				

Field

Contents

SID Load set identification number (Integer > 0)
 G Grid point identification number (Integer > 0)
 F Value of load (Real)
 G1, G2 Grid point identification numbers (Integer > 0; G1 ≠ G2)

Remarks: 1. The direction of the force is determined by the vector from G1 to G2.
 2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FØRCE2 Static Load

Description: Used to define a static load by specification of a value and four grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCE2	SID	G	F	G1	G2	G3	G4		
FØRCE2	6	13	-2.93	16	13	17	13		

Field

Contents

SID Load set identification number (Integer > 0)
 G Grid point identification number (Integer > 0)
 F Value of load (Real)
 G1,G2,G3,G4 Grid point identification numbers (Integer > 0; G1 ≠ G2; G3 ≠ G4)

- Remarks:
1. The direction of the force is determined by the vector product whose factors are vectors from G1 to G2 and G3 to G4 respectively.
 2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FØRCEAX

Axisymmetric Static Load

Description: Defines a static loading for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FØRCEAX	SID	RID	HID	S	FR	FP	FZ		
FØRCEAX	1	2	3	2.0	0.1	0.2	0.3		

Field

Contents

SID	Load set identification number (Integer > 0)
RID	Ring identification number (see RINGAX) (Integer > 0)
HID	Harmonic identification number (Integer ≥ 0 or a sequence of harmonics, see note 5)
S	Scale factor for load (Real)
FR } FP } FZ }	Load components in r, ϕ , z directions (Real)

- Remarks:
1. This card is allowed if and only if an AXIC card is also present.
 2. Axisymmetric loads must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
 3. A separate card is needed for the definition of the force associated with each harmonic.
 4. If a sequence of harmonics is to be placed in HID the form is as follows: "Sn1Tn2" where n1 is the start of the sequence and n2 is the end of the sequence. i.e., harmonics 0 through 10, the field would contain "SOT10".
 5. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
 6. For a discussion of the axisymmetric solid problem see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK


BULK DATA DECK

Input Data Card FREEPT

Fluid Free Surface Point

Description: Defines the location of points on the surface of a fluid for recovery of surface displacements in a gravity field.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREEPT	IDF		IDP	ϕ	IDP	ϕ	IDP	ϕ	
FREEPT	3		301	22.5	302	90.0	303	370.0	

Field

Contents

IDF Fluid point (RINGFL) identification number (Integer > 0)
 IDP Free surface point identification number (Integer > 0)
 ϕ Azimuthal position of FREEPT on fluid point (RINGFL), in Fluid Coordinate System (Real)

- Remarks:
1. This card is allowed only if an AXIF card is also present.
 2. All free surface point identification numbers must be unique with respect to other scalar, structural and fluid points.
 3. The free surface points are used for the identification of output data only.
 4. Three points may be defined on a single card.
 5. The referenced fluid point (IDF) must be included in a free surface list (FSLIST).
 6. Output requests for velocity and acceleration can be made at these points.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FREQ Frequency List

Description: Defines a set of frequencies to be used in the solution of frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREQ	SID	F	F	F	F	F	F	F	abc
FREQ	3	2.98	3.05	17.9	21.3	25.6	28.8	31.2	ABC
+bc	F	F	F	F	F	F	F	F	
+BC	29.2	22.4	19.3						

-etc.-

Field

Contents

SID Frequency set identification number (Integer > 0)

F Frequency value (Real > 0.0)

- Remarks:
1. The units for the frequencies are cycles per unit time.
 2. Frequency sets must be selected in the Case Control Deck (FREQ=SID) to be used by NASTRAN.
 3. All FREQ, FREQ1 and FREQ2 cards must have unique frequency set identification numbers.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FREQ1

Frequency List

Description: Defines a set of frequencies to be used in the solution of frequency response problems by specification of a starting frequency, frequency increment, and number of increments desired.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREQ1	SID	F1	DF	NDF					
FREQ1	6	2.9	0.5	13					

Field

Contents

SID Frequency set identification number (Integer > 0)
 F1 First frequency in set (Real ≥ 0.0)
 DF Frequency increment (Real > 0.0)
 NDF Number of frequency increments (Integer > 0)

- Remarks:
1. The units for the frequency F1 and the frequency increment DF are cycles per unit time.
 2. The frequencies defined by this card are given by

$$f_i = F1 + (i - 1) DF, \quad i = 1, NDF + 1$$
 3. Frequency sets must be selected in the Case Control Deck (FREQ=SID) to be used by NASTRAN.
 4. All FREQ, FREQ1 and FREQ2 cards must have unique frequency set identification numbers.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FREQ2 Frequency List

Description: Defines a set of frequencies to be used in the solution of frequency response problems by specification of a starting frequency, final frequency, and number of logarithmic increments desired.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FREQ2	SID	F1	F2	NF					
FREQ2	6	1.0	1.E5	5					

<u>Field</u>	<u>Contents</u>
SID	Frequency set identification number (Integer > 0)
F1	First frequency (Real > 0.0)
F2	Last frequency (Real > 0.0; F2 > F1)
NF	Number of logarithmic intervals (Integer > 0)

- Remarks:
1. The units for the frequencies F1 and F2 are cycles per unit time.
 2. The frequencies defined by this card are given by

$$f_i = F1 \cdot e^{(i-1)d}, \quad i = 1, 2, \dots, NF + 1$$

where

$$d = \frac{1}{NF} \log_e \frac{F2}{F1}$$

For the example shown, the list of frequencies will be 1.0, 10.0, 100.0, 1000.0, 10000.0, and 100000.0 cycles per unit time.

3. Frequency sets must be selected in the Case Control Deck (FREQ=SID) to be used by NASTRAN.
4. All FREQ, FREQ1 and FREQ2 cards must have unique frequency set identification numbers.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card FSLIST

Free Surface List

Description: Declares the fluid points (RINGFL) which lie on a free surface boundary.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FSLIST	RHØ	IDF1	IDF2	IDF3	IDF4	IDF5	IDF6	IDF7	abc
FSLIST	1.0-4	1	3	5	4	2	7	6	+12FS
+bc	IDF8	IDF9	-etc.-						def
+12FS	8	9	10	11	AXIS				

-etc.-

Field

Contents

RHØ Mass density at the surface (Real > 0.0 or blank; if blank the AXIF default value must not be blank)

IDFi Identification number of RINGFL point (Integer > 0 or BCD, "AXIS." The first and/or last entry may be AXIS)

- Remarks:
1. This card is allowed only if an AXIF card is also present.
 2. Each logical card defines a surface. The order of the points must be sequential with the fluid on the right with respect to the direction of travel.
 3. The BCD word, AXIS, defines an intersection with the polar axis of the Fluid Coordinate System.
 4. There may be as many FSLIST cards as the user requires. If the fluid density varies along the boundary there must be one FSLIST card for each interval between fluid points.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card GENEL

General Element

Description: Defines a general element using either:

1. The stiffness approach:

$$\begin{Bmatrix} f_i \\ f_d \end{Bmatrix} = \begin{bmatrix} K & | & -KS \\ -S^T K & | & S^T KS \end{bmatrix} \begin{Bmatrix} u_i \\ u_d \end{Bmatrix}, \text{ or}$$

2. The flexibility approach:

$$\begin{Bmatrix} u_i \\ f_d \end{Bmatrix} = \begin{bmatrix} Z & | & \bar{S} \\ -S^T & | & 0 \end{bmatrix} \begin{Bmatrix} f_i \\ u_d \end{Bmatrix}, \text{ where}$$

$$\{u_i\} = [u_{i1}, u_{i2}, \dots, u_{im}]^T,$$

$$\{u_d\} = [u_{d1}, u_{d2}, \dots, u_{dn}]^T,$$

$$[KZ] = [K] \text{ or } [Z] = \begin{bmatrix} KZ_{11} & KZ_{12} & \dots & KZ_{1m} \\ \vdots & KZ_{22} & \dots & \vdots \\ \vdots & \vdots & \dots & \vdots \\ KZ_{m1} & \dots & \dots & KZ_{mn,1} \end{bmatrix} \text{ and } [KZ]^T = [KZ],$$

$$[S] = \begin{bmatrix} S_{11} & \dots & \dots & S_{1n} \\ \vdots & & & \vdots \\ \vdots & & & \vdots \\ S_{m1} & \dots & \dots & S_{mn} \end{bmatrix}.$$

The required input is the $\{u_i\}$ list and the lower triangular portion of $[K]$ or $[Z]$.

Additional input may include the $\{u_d\}$ list and $[S]$. If $[S]$ is input, $\{u_d\}$ must also be input.

If $\{u_d\}$ is input but $[S]$ is omitted, $[S]$ is internally calculated. In this case, $\{u_d\}$ must have six and only six degrees of freedom. If $[S]$ is not required, both $\{u_d\}$ and $[S]$ are omitted.

NASTRAN DATA DECK

GENEL (Cont.)

Format: (An example is given on the following page.)

1	2	3	4	5	6	7	8	9	10
GENEL	EID		UI1	CI1	UI2	CI2	UI3	CI3	X1
+1	UI4	CI4	UI5	CI5	UI6	CI6	UI7	CI7	X2
+2				Etc.					X3
+3	UI_m - The last item in the UI-list will appear in one of fields 2, 4, 6, or 8.								X4
+4	"UD"		UD1	CD1	UD2	CD2	UD3	CD3	X5
+5				Etc.					X6
+6	UD_n - The last item in the UD list will appear in one of fields 2, 4, 6, or 8.								X7
+7	"K" or "Z"	KZ11	KZ21	KZ31	Etc.		KZ22	KZ32	X8
+8	Etc.		KZ33	KZ43	Etc.				X9
+9				Etc.					X10
+10	KZ_{mm} - The last item in the K or Z matrix, will appear in one of fields 2 through 9.								X11
+11	"S"	S11	S12	Etc.		S21	Etc.		X12
+12	S_{mn} - The last item in the S matrix will appear in one of fields 2 through 9.								

Field

Contents

EID Unique element identification number, a positive integer.

$\left. \begin{array}{l} UI1, CI1 \\ \text{Etc.} \\ UD1, ED1 \\ \text{Etc.} \end{array} \right\}$ Identification numbers of coordinates in the UI or UD list, in sequence corresponding to the [K], [Z], and [S] matrices. U_i and UD_i are grid point numbers, and CI_i and CD_i are the component numbers. If a scalar point is given, the component number is zero.

KZ_{ij} Values of the [K] or [Z] matrix ordered by columns from the diagonal, according to the UI list.

S_{ij} Values of the [S] matrix ordered by rows, according to the UD list.

$\left. \begin{array}{l} \text{"UD", "K",} \\ \text{"Z", and} \\ \text{"S"} \end{array} \right\}$ BCD data words which indicate the start of data belonging to UD, [K], [Z], or [S].

Remarks: 1. When the stiffness matrix, K, is input, the number of significant digits should be the same for all terms.

2. Double-field format may be used for input of K or Z.

BULK DATA DECK

GENEL (Cont.)

Example: Let element 629 be defined by

$$\{u_i\} = [1-1, 13-4, 42, 24-2]^T,$$

$$\{u_d\} = [6-2, 33]^T,$$

where i-j means the jth component of grid point i. Points 42 and 33 are scalar points.

$$[K] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 2.0 & 5.0 & 6.0 & 7.0 \\ 3.0 & 6.0 & 8.0 & 9.0 \\ 4.0 & 7.0 & 9.0 & 0.0 \end{bmatrix}, \quad [S] = \begin{bmatrix} 1.5 & 2.5 \\ 3.5 & 4.5 \\ 5.5 & 6.5 \\ 7.5 & 8.5 \end{bmatrix}$$

The data cards necessary to input this general element are shown below:

1	2	3	4	5	6	7	8	9	10
GENEL	629		1	1	13	4	42	0	X1
+1	24	2							X2
+2	UD		6	2	33	0			X3
+3	Z	1.0	2.0	3.0	4.0	5.0	6.0	7.0	X4
+4	8.0	9.0	0.0						X5
+5	S	1.5	2.5	3.5	4.5	5.5	6.5	7.5	X6
+6	8.5								

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card GRAV Gravity Vector

Description: Used to define gravity vectors for use in determining gravity loading for the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRAV	SID	CID	G	N1	N2	N3			
GRAV	1	3	32.2	0.0	0.0	-1.0			

<u>Field</u>	<u>Contents</u>
SID	Set identification number (Integer > 0)
CID	Coordinate system identification number (Integer ≥ 0)
G	Gravity vector scale factor (Real)
N1, N2, N3	Gravity vector components (Real; $N1^2 + N2^2 + N3^2 > 0.0$)

Remarks: 1. The gravity vector is defined by

$$\vec{g} = G \cdot (N1, N2, N3).$$

2. A CID of zero references the basic coordinate system.
3. Gravity loads may be combined with "simple loads" (e.g., FORCE, MOMENT) only by specification on a LOAD card. That is, the SID on a GRAV card may not be the same as that on a simple load card.
4. Load sets must be selected in the Case Control Deck (LOAD=SID) to be used by NASTRAN.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card GRDSET

Grid Point Default

Description: Defines default options for fields 3, 7 and 8 of all GRID cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRDSET		CP				CD	PS		
GRDSET		16				32	3456		

Field

Contents

- CP Identification number of coordinate system in which the location of the grid point is defined (Integer ≥ 0)
- CD Identification number of coordinate system in which displacements are measured at grid point (Integer ≥ 0)
- PS Permanent single-point constraints associated with grid point (any of the digits 1-6 with no imbedded blanks) (Integer ≥ 0)

- Remarks:
1. The contents of fields 3, 7 or 8 of this card are assumed for the corresponding fields of any GRID card whose fields 3, 7 and 8 are blank. If any of these fields on the GRID card are blank, the default option defined by this card occurs for that field. If no permanent single-point constraints are desired or one of the coordinate systems is basic, the default may be overridden on the GRID card by making one of fields 3, 7 or 8 zero (rather than blank). Only one GRDSET card may appear in the user's Bulk Data Deck.
 2. The primary purpose of this card is to minimize the burden of preparing data for problems with a large amount of repetition (e.g., two-dimensional pinned-joint problems).
 3. At least one of the entries CP, CD, or PS must be nonzero.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card GRID

Grid Point

Description: Defines the location of a geometric grid point of the structural model, the directions of its displacement, and its permanent single-point constraints.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRID	ID	CP	X1	X2	X3	CD	PS		
GRID	2	3	1.0	2.0	3.0		316		

Field

Contents

ID Grid point identification number (0<Integer<999999)

CP Identification number of coordinate system in which the location of the grid point is defined (Integer ≥ 0 or blank*).

X1,X2,X3 Location of the grid point in coordinate system CP (Real)

CD Identification number of coordinate system in which displacements, degrees of freedom, constraints, and solution vectors are defined at the grid point (Integer ≥ 0 or blank*).

PS Permanent single-point constraints associated with grid point (any of the digits 1-6 with no imbedded blanks) (Integer ≥ 0 or blank*)

- Remarks:**
1. All grid point identification numbers must be unique with respect to all other structural, scalar, and fluid points.
 2. The meaning of X1, X2 and X3 depend on the type of coordinate system, CP, as follows: (see CORD__ card descriptions)

Type	X1	X2	X3
Rectangular	X	Y	Z
Cylindrical	R	θ(degrees)	Z
Spherical	R	θ(degrees)	φ(degrees)

3. The collection of all CD coordinate systems defined on all GRID cards is called the Global Coordinate System. All degrees-of-freedom, constraints, and solution vectors are expressed in the Global Coordinate System.

* See the GRDSET card for default options for fields 3, 7 and 8.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card GRIDB

Axisymmetric Problem Grid Point

Description: Defines the location of a geometric grid point on a RINGFL for an axisymmetric fluid model and/or axisymmetric structure. Used to define the boundary of the fluid.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRIDB	ID			ϕ		CD	PS	IDF	
GRIDB	30			30.0		3	345	20	

Field

Contents

ID	Grid point identification number (Integer > 0)
ϕ	Azimuthal position in the fluid in degrees (Real)
CD	Identification number of the coordinate system in which displacements are defined at the grid point (Integer ≥ 0)
PS	Permanent single-point constraints associated with the grid point (any combination of the digits 1-6 with no embedded blanks) (Integer ≥ 0)
IDF	Identification number of a RINGFL (Integer > 0)

- Remarks:
1. This card is allowed only if an AXIF card is also present.
 2. All GRIDB identification numbers must be unique with respect to other scalar, structural and fluid points.
 3. An AXIF card must define a Fluid Coordinate System.
 4. The RINGFL referenced must be present.
 5. If no harmonic numbers on the AXIF card are specified, no fluid elements are necessary.
 6. The collection of all CD coordinate systems defined on all GRID and GRIDB cards is called the Global Coordinate System.
 7. Fields 3, 4, and 6 are ignored. This will facilitate the user's conversion of GRID cards to GRIDB cards. Note that the fields are the same except for fields 1 and 9 if a cylindrical coordinate system is used.
 8. The referenced RINGFL point must be included in a boundary list (BDYLIST data card).

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card GRIDF Fluid Point

Description: Defines a scalar degree of freedom for harmonic analysis of a fluid.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRIDF	ID	R	Z						
GRIDF	23	2.5	-7.3						

<u>Field</u>	<u>Contents</u>
ID	Identification number of axisymmetric fluid point (Integer > 0)
R	Radial location of point in basic coordinate system (Real > 0.0)
Z	Axial location of point in basic coordinate system (Real)

- Remarks:
1. This card is allowed only if an AXSLØT card is also present.
 2. The identification number (ID) must be unique with respect to all other scalar, structural and fluid points.
 3. Grid points on slot boundaries are defined on GRIDS cards. Do not also define them on GRIDF cards.
 4. For plotting purposes the R location corresponds to the basic X coordinate. The Z location corresponds to the basic Y coordinate. Pressures will be plotted as displacement in the basic Z direction.
 5. Load and constraint conditions are applied as if the GRIDF is a scalar point. Positive loads correspond to inward flow and a single point constraint causes zero pressure at the point.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card GRIDS

Slot Surface Point

Description: Defines a scalar degree of freedom with a two dimensional location. Used in defining pressure in slotted acoustic cavities.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRIDS	ID	R	Z	W	IDF				
GRIDS	25	2.5	-7.3	0.5					

Field

Contents

ID	Identification number of slot point (Integer > 0)
R	Radial location of point in basic coordinate system (Real ≠ 0.0)
Z	Axial location of point in basic coordinate system (Real)
W	Slot width or thickness at the GRIDS point (Real ≥ 0.0, or blank)
IDF	Identification number to define a GRIDF point (Integer > 0, or blank)

- Remarks:
1. This card is allowed only if an AXSLØT card is also present.
 2. The identification numbers (ID and IDF if present) must be unique with respect to all other scalar, structural and fluid points.
 3. If W is "blank", the default value on the AXSLØT card will be used.
 4. The IDF number is referenced on the CAXIFi card for central cavity fluid elements next to the interface. The IDF number is entered only if the grid point is on an interface. In this case it should not also be defined on a GRIDF card.
 5. If IDF is nonzero then R must be greater than zero.
 6. For plotting purposes the R location corresponds to the basic X coordinate. The Z location corresponds to the basic Y coordinate. The slot width, W, corresponds to the basic Z coordinate. The pressure will be plotted in the basic Z direction.
 7. Load and constraint conditions are applied as if the GRIDS is a scalar point. Positive loads correspond to inward flow and a single point constraint causes zero pressure at the point.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card GTRAN Grid Point Transformation

Description: This card defines the output coordinate system transformation to be applied to the displacement set of a selected grid point.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GTRAN	SID	NAME	GID	TRAN					
GTRAN	44	GIMBAL	1067	45					

Field

Contents

SID Identification number of the transformation set (Integer > 0)
NAME Basic substructure name (BCD)
GID Grid point identification (Integer > 0)
TRAN Identification number of a TRANS bulk data card (Integer ≥ 0)

- Remarks:
1. If TRAN = 0, the displacement set at the grid point will be transformed to the overall basic coordinate system.
 2. If TRAN = SID, the point will remain fixed to the substructure (i.e., no transformation occurs).
 3. Otherwise, the displacement set at the grid point will be transformed to the coordinate system directions defined by the selected TRANS card.
 4. Transformation sets must be selected in the Substructure Control Deck (TRANS=SID) to be used by NASTRAN. Note that 'TRANS' is a subcommand of the substructure COMBINE command.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card LØAD Static Load Combination (Superposition)

Description: Defines a static load as a linear combination of load sets defined via FØRCE, MØMENT, FØRCE1, MØMENT1, FØRCE2, MØMENT2, PLØAD, PLØAD2, PLØAD3, FØRCEAX, PRESAX, MØMAX, SLØAD, RFØRCE and GRAV cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
LØAD	SID	S	S1	L1	S2	L2	S3	L3	abc
LØAD	101	-0.5	1.0	3	6.2	4			
+bc	S4	L4		-etc.-					

(etc.)

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scale factor (Real)
S1	Scale factors (Real)
L1	Load set identification numbers defined via card types enumerated above (Integer > 0)

Remarks: 1. The load vector defined is given by

$$\{P\} = S \sum_i S_i \{P_{Li}\}$$

- The Li must be unique. The remainder of the physical card containing the last entry must be blank.
- This card must be used if gravity loads (GRAV) are to be used with any of the other types.
- Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
- A LØAD card may not reference a set identification number defined by another LØAD card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card LØADC

Substructure Static Loading Combination

Description: Defines the static load for a substructuring analysis as a linear combination of load sets defined for each component substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
LØADC	SID	S	NAME1	ID1	S1	NAME2	ID2	S2	abc
LØADC	27	1.0	WINGRT	5	0.5	FUSELAGE	966	2.5	ABC
+bc			NAME3	ID3	S3	NAME4	ID4	S4	def
+BC			MIDWG	27	1.75	etc.			

Field

Contents

SID Load set identification number (Integer > 0)
 S Scale factor applied to final load vector (Real)
 NAMEi Basic substructure name (BCD)
 IDi Load set identification number of substructure NAMEi (Integer > 0)
 Si Scale factor (Real)

Remarks: 1. The load vector is combined by:

$$\{P\} = S \sum_i S_i \{P\}_{IDi}$$

2. The load set identification numbers (IDi) reference the load sets used in Phase 1 to generate the load vectors on the basic substructures.
3. The NAMEi and IDi need not be unique.
4. The LØADC card is the means of specifying a static loading condition in a Phase 2 substructure analysis. The IDi may actually reference temperature loads or element deformation loads defined in Phase 1.
5. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MAT1 Material Property Definition

Description: Defines the material properties for linear, temperature-independent, isotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT1	MID	E	G	NU	RHØ	A	TREF	GE	+abc
MAT1	17	3.+7	1.9+7		4.28	0.19	5.37+2	0.23	ABC
+abc	ST	SC	SS						
+BC	20.+4	15.+4	12.+4						

<u>Field</u>	<u>Contents</u>
MID	Material identification number (Integer > 0)
E	Young's modulus (Real ≥ 0.0 or blank)
G	Shear modulus (Real ≥ 0.0 or blank)
NU	Poisson's ratio ($-1.0 < \text{Real} \leq 0.5$ or blank)
RHØ	Mass density (Real)
A	Thermal expansion coefficient (Real)
TREF	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)
ST, SC, SS	Stress limits for tension, compression and shear (Real) (Required for Property Optimization calculations; otherwise optional if margins of safety are desired.)

- Remarks:
- One of E or G must be positive (i.e., either $E > 0.0$ or $G > 0.0$ or both E and G may be > 0.0).
 - If any one of E, G or NU is blank, it will be computed to satisfy the identity $E = 2(1+\text{NU})G$; otherwise, values supplied by the user will be used.
 - The material identification number must be unique for all MAT1, MAT2 and MAT3 cards.
 - MAT1 materials may be made temperature dependent by use of the MATT1 card.
 - The mass density, RHØ, will be used to automatically compute mass for all structural elements except the two-dimensional bending only elements TRBSC, TRPLT and QDPLT.
 - If E and NU or G and NU are both blank they will be both given the value 0.0.
 - Weight density may be used in field 6 if the value $\frac{1}{g}$ is entered on the PARAM card WTMAS, where g is the acceleration of gravity.
 - Solid elements must not have NU equal to 0.5.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MAT2

Material Property Definition

Description: Defines the material properties for linear, temperature-independent, anisotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT2	MID	G11	G12	G13	G22	G23	G33	RHØ	+abc
MAT2	13	6.2+3			6.2+3		5.1+3	0.056	ABC
+abc	A1	A2	A12	T0	GE	ST	SC	SS	
+BC	0.15			-500.0	0.002	20.+5			

Field

Contents

MID	Material identification number (Integer > 0)
Gij	The material property matrix (Real)
RHØ	Mass density (Real)
Ai	Thermal expansion coefficient vector (Real)
T0	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)
ST, SC, SS	Stress limits for tension, compression and shear (Real) (Used only to compute margins of safety in certain elements; they have no effect on the computational procedures)

- Remarks:
1. The material identification numbers must be unique for all MAT1, MAT2 and MAT3 cards.
 2. MAT2 materials may be made temperature dependent by use of the MATT2 card.
 3. The mass density, RHØ, will be used to automatically compute mass for all structural elements except the two-dimensional bending only elements TRBSC, TRPLT and QDPLT.
 4. The convention for the G_{ij} in fields 3 through 8 is represented by the matrix relationship.

$$\begin{pmatrix} \sigma_1 \\ \sigma_2 \\ \tau_{12} \end{pmatrix} = \begin{bmatrix} G_{11} & G_{12} & G_{13} \\ G_{12} & G_{22} & G_{23} \\ G_{13} & G_{23} & G_{33} \end{bmatrix} \begin{pmatrix} \epsilon_1 \\ \epsilon_2 \\ \gamma_{12} \end{pmatrix}$$

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MAT3

Material Property Definition

Description: Defines the material properties for linear, temperature-independent, orthotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT3	MID	EX	EY	EZ	NUXY	NUYZ	NUZX	RHØ	+abc
MAT3	23	1.0+7	1.1+7	1.2+7	.3	.25	.27	1.0-5	ABC
+abc	GXY	GYZ	GZX	AX	AY	AZ	TREF	GE	
+BC	2.5+6	3.0+6	2.5+6	1.0-4	1.0-4	1.1-4	68.5	.23	

Field

Contents

MID	Material identification number (Integer > 0)
EX, EY, EZ	Young's moduli in the x, y and z directions respectively (Real ≥ 0.0)
NUXY,NUYZ,NUZX	Poisson's Ratios (Coupled strain ratios in the xy, yz and zx directions respectively) (Real)
RHØ	Mass density (Real)
GXY, GYZ, GZX	Shear moduli for xy, yz and zx (Real ≥ 0.0)
AX, AY, AZ	Thermal expansion coefficients (Real)
TREF	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)

- Remarks:
1. The material identification number must be unique with respect to the collection of all MATi cards.
 2. MAT3 materials may be made temperature-dependent by use of the MATT3 card.
 3. All nine of the numbers EX, EY, EZ, NUXY, NUYZ, NUZX, GXY, GYZ and GZX must be present.
 4. A nonfatal warning diagnostic will occur if any of NUXY or NUYZ has an absolute value greater than 1.0.
 5. MAT3 materials may only be referenced by CTIRARG, CTAPRG, CTIRIAX, CTAPAX, and PTØRDRG cards.
 6. The mass density, RHØ, will be used to automatically compute mass for the TRIARG, TRAPRG, CTIRIAX, CTAPAX and TØRDRG elements.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MAT4

Thermal Material Property Definition

Description: Defines the thermal material properties for temperature-independent, isotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT4	MID	K	CP						
MAT4	103	.6	.2						

Field

Contents

MID Material identification number (Integer > 0)

K Thermal conductivity (Real > 0.0), or convective film coefficient

CP Thermal capacity per unit volume (Real > 0.0 or blank), or film capacity per unit area

Remarks:

1. The material identification number may be the same as a MAT1, MAT2, or MAT3 card, but must be unique with respect to other MAT4 or MAT5 cards.
2. If a HBDY element references this card, K is the convective film coefficient and CP is the thermal capacity per unit area.
3. MAT4 materials may be made temperature dependent by use of the MATT4 card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MAT5

Thermal Material Property Definition

Description: Defines the thermal material properties for temperature-independent, anisotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT5	MID	KXX	KXY	KXZ	KYY	KYZ	KZZ	CP	
MAT5	24	.092			.083		.020	0.2	

Field

Contents

MID Material identification number (Integer > 0)

KXX,KXY,KXZ,
KYY,KYZ,KZZ Thermal conductivity (Real)

CP Thermal capacity per unit volume (Real \geq 0.0 or blank)

Remarks:

1. The thermal conductivity matrix has the form:

$$K = \begin{bmatrix} KXX & KXY & KXZ \\ KXY & KYY & KYZ \\ KXZ & KYZ & KZZ \end{bmatrix}$$

2. The material number may be the same as a MAT1, MAT2, or MAT3 card, but must be unique with respect to the MAT4 or MAT5 cards.
3. MAT5 materials may be made temperature dependent by use of the MATT5 card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MATS1 Material Stress Dependence

Description: Specifies table references for material properties which are stress-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATS1	MID	R1							+abc
MATS1	17	28							ABC

Field

Contents

MID Material property identification number which matches the identification number on some basic MAT1 card (Integer > 0)

R1 Reference to table identification number (Integer ≥ 0)

Remarks: 1. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT1 card.

2. TABLES1 type tables must be used.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MATT1 Material Temperature Dependence

Description: Specifies table references for material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT1	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT1	17	32				15			ABC
+abc	R8	R9	R10						
+BC	62								

<u>Field</u>	<u>Contents</u>
MID	Material property identification number which matches the identification number on some basic MAT1 card (Integer > 0)
Ri	References to table identification numbers (Integer \geq 0)

- Remarks:
- Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT1 card.
 - TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MATT2 Material Temperature Dependence

Description: Specifies table references for material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT2	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT2	17	32				15			ABC
+abc	R8	R9	R10	R11	R12	R13	R14	R15	
+BC	62								

Field

Contents

MID Material property identification number which matches the identification number on some basic MAT2 card (Integer > 0)

Ri References to table identification numbers (Integer ≥ 0)

Remarks:

- Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT2 card.
- TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MATT3

Material Temperature Dependence

Description: Specifies table references for orthotropic, "MAT3", material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT3	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT3	23	48			54				ABC
+abc	R8	R9	R10	R11	R12	R13	R14	R15	
+BC	74								

Field

Contents

MID Material property identification number which matches the identification number on some basic MAT3 card (Integer > 0)

Ri References to table identification numbers (Integer ≥ 0)

Remarks: 1. Blank or zero entries imply no table dependence of the referenced quantity on the basic MAT3 card.

2. TABLE1, TABLE2, TABLE3 or TABLE4 type tables may be used.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MATT4

Thermal Material Temperature Dependence

Description: Specifies table reference for temperature dependent thermal conductivity or convective film coefficient.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT4	MID	T(K)							
MATT4	103	73							

Field

Contents

MID ID of a MAT4 which is to be temperature dependent (Integer > 0)

T(K) Identification number of a TABLEM_i card which gives temperature dependence of the thermal conductivity or convective film coefficient (Integer > 0 or blank)

Remarks:

1. The thermal capacity may not be temperature dependent; field 4 must be blank.
2. TABLEM₁, TABLEM₂, TABLEM₃, or TABLEM₄ type tables may be used. The basic quantities on the MAT4 card is always multiplied by the tabular function. Note that this is different from structural applications.
3. Blank or zero entries means no table dependence of the referenced quantity on the basic MAT4 card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MATT5

Thermal Material Temperature Dependence

Description: Specifies table references for temperature dependent conductivity matrix.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT5	MID	T(KXX)	T(KXY)	T(KXZ)	T(KYY)	T(KYZ)	T(KZZ)		
MATT5	24	73							

Field

Contents

MID Identification number of a MAT5, which is to be temperature dependent (Integer > 0)

T(K--) Identification number of a TABLEMi card which gives temperature dependence of the matrix term (Integer > 0 or blank)

Remarks:

1. The thermal capacity may not be temperature dependent. Field 9 must be blank.
2. TABLEM1, TABLEM2, TABLEM3, or TABLEM4 type tables may be used. The basic quantities on the MAT5 card are always multiplied by the tabular function. Note that this is different from the structural applications.
3. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT5 card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MKAER01 Mach Number - Frequency Table

Description: Provides a table of Mach numbers (m) and reduced frequencies (k) for aerodynamic matrix calculation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MKAER01	m_1	m_2	m_3	m_4	m_5	m_6	m_7	m_8	ABC
MKAER01	.1	.7							+ABC
+BC	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	
+BC	.3	.6	1.0						

Field

Contents

m_i List of Mach numbers (Real, $1 \leq i \leq 8$).

k_j List of reduced frequencies (Real, $1 \leq j \leq 8$).

Remarks:

1. Blank fields end the list, and thus cannot be used for 0.0.
2. All combinations of (m, k) will be used.
3. The continuation card is required.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MKAER02 Mach Number - Frequency Table

Description: Provides a list of Mach numbers (m) and reduced frequencies (k) for aerodynamic matrix calculation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MKAER02	m_1	k_1	m_2	k_2	m_3	k_3	m_4	k_4	
MKAER02	.10	.30	.10	.60	.70	.30	.70	1.0	

Field

Contents

m_i, k_i List of pairs of Mach numbers (Real) and reduced frequencies (Real) (imbedded blank pairs are skipped).

Remarks:

1. This card will cause the aerodynamic matrices to be computed for a set of parameter pairs.
2. Several MKAER02 cards may be in the deck.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MØMAX

Conical Shell Static Moment

Description: Defines a static moment loading of a conical shell coordinate.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMAX	SID	RID	HID	S	MR	MP	MZ		
MØMAX	1	2	3	1.0	0.1	0.2	0.3		

<u>Field</u>	<u>Contents</u>
SID	Load set identification number (Integer > 0)
RID	Ring identification number (see RINGAX)(Integer > 0)
HID	Harmonic identification number (Integer ≥ 0 or a sequence of harmonics, see note 5)
S	Scale factor (Real)
MR } MP } MZ }	Moment components in the r, ϕ , z directions (Real)

- Remarks:
1. This card is allowed if and only if an AXIC card is also present.
 2. Load sets must be selected in the Case Control Deck (LOAD=SID) to be used by NASTRAN.
 3. A separate card is needed for the definition of the moment associated with each harmonic.
 4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
 5. If a sequence of harmonics is to be placed in HID the form is as follows:
"Sn1Tn2" where n1 is the start of the sequence and n2 is the end of the sequence
i.e., for harmonics 0 through 10, the field would contain "SOT10".

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MØMENT Static Moment

Description: Defines a static moment at a grid point by specifying a vector.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMENT	SID	G	CID	M	N1	N2	N3		
MØMENT	2	5	6	2.9	0.0	1.0	0.0		

<u>Field</u>	<u>Contents</u>
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
CID	Coordinate system identification number (Integer ≥ 0)
M	Scale factor (Real)
N1,N2,N3	Components of Vector measured in coordinate system defined by CID (Real; $N1^2 + N2^2 + N3^2 > 0.0$)

Remarks: 1. The static moment applied to grid point G is given by

$$\vec{m} = M \cdot (N1, N2, N3)$$

2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
3. A CID of zero references the basic coordinate system.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MØMENT1

Static Moment

Description: Used to define a static moment by specification of a value and two grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMENT1	SID	G	M	G1	G2				
MØMENT1	6	13	-2.93	16	13				

Field

Contents

SID Load set identification number (Integer > 0)
 G Grid point identification number (Integer > 0)
 M Value of moment (Real)
 G1, G2 Grid point identification numbers (Integer > 0; G1 ≠ G2)

Remarks: 1. The direction of the moment is determined by the vector from G1 to G2.
 2. Load sets must be selected in the Case Control Deck (LOAD-SID) to be used by NASTRAN.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MØMENT2

Static Moment

Description: Used to define a static moment by specification of a value and four grid points which determine the direction.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MØMENT2	SID	G	M	G1	G2	G3	G4		
MØMENT2	6	13	-2.93	16	13	17	13		

Field

Contents

SID Load set identification number (Integer > 0)
 G Grid point identification number (Integer > 0)
 M Value of moment (Real)
 G1,G2,G3,G4 Grid point identification numbers (Integer > 0; G1 ≠ G2; G3 ≠ G4)

Remarks: 1. The direction of the force is determined by the vector product whose factors are vectors from G1 to G2 and G3 to G4 respectively.
 2. Load sets must be selected in the Case Control Deck (LOAD=SID) to be used by NASTRAN.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MPC

Multipoint Constraint

Description: Defines a multipoint constraint equation of the form

$$\sum_j A_j u_j = 0$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPC	SID	G	C	A	G	C	A		abc
MPC	3	28	3	6.2	2		4.29		+B
+bc		G	C	A	-etc.-				
+B		1	4	-2.91					

Field

Contents

SID Set identification number (Integer > 0)
 G Identification number of grid or scalar point (Integer > 0)
 C Component number - any one of the digits 1-6 in the case of geometric grid points; blank or zero in the case of scalar points (Integer)
 A Coefficient (Real; the first A must be nonzero)

- Remarks:
1. The first coordinate in the sequence is assumed to be the dependent coordinate and must be unique for all equations of the set.
 2. Forces of multipoint constraint are not recovered.
 3. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
 4. Dependent coordinates on MPC cards may not appear on OMIT, OMIT1, SUPORT, SPC or SPC1 cards; nor may the dependent coordinates be redundantly implied on ASET, ASET1, or MPCADD cards.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MPCADD

Multipoint Constraint Set Definition

Description: Defines a multipoint constraint set as a union of multipoint constraint sets defined via MPC cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCADD	SID	S1	S2	S3	S4	S5	S6	S7	abc
MPCADD	101	2	3	1	6	4			
+bc	S8	S9	-etc.-						

Field

Contents

SID Set identification number (Integer > 0)

Sj Set identification numbers of multipoint constraint sets defined via MPC cards (Integer > 0)

Remarks: 1. The Sj must be unique.

2. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
3. Sj may not be the identification number of a multipoint constraint set defined by another MPCADD card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MPCAX

Axisymmetric Multipoint Constraint

Description: Defines a multipoint constraint equation of the form

$$\sum_j A_j u_j = 0$$

for a model containing CCONEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCAX	SID				RID	HID	C	A	+abc
MPCAX	32				17	6	1	1.0	+1
+abc	RID	HID	C	A	RID	HID	C	A	+def
+1	23	4	2	-6.8					

-etc.-

<u>Field</u>	<u>Contents</u>
SID	Set identification number (Integer > 0)
RID	Ring identification number (Integer > 0)
HID	Harmonic identification number (Integer > 0)
C	Component number (1 ≤ Integer ≤ 6)
A	Coefficient (Real; the first A must be nonzero)

- Remarks:
1. This card is allowed if and only if an AXIC card is also present.
 2. The first coordinate in the sequence is assumed to be the dependent coordinate and must be unique for all equations of the set.
 3. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
 4. Dependent coordinates appearing on MPCAX cards may not appear on OMITAX, SPCAX, or SUPAX cards.
 5. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
 6. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card MPCS

Substructure Multipoint Constraints

Description: Defines multipoint constraints within or between substructures.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCS	SID	NAME1	G1	C1	A1				abc
MPCS	171	WINGRT	966	1	1.0				ABC
+bc		NAME2	G21	C21	A21	G22	C22	A32	def
+BC		FUSELAGE	1036	1	.031	1036	6	32.7	DEF
+ef		NAME3	G31	C31	A31	G32	C32	A32	ghi
+EF		CABIN	39	2	.076				

Field

Contents

SID	Set identification number (Integer > 0)
NAMEi	Basic substructure name (BCD)
Gi	Grid or scalar point identification number in basic substructure NAME or NAMEi (Integer > 0)
Ci	Component number - Any one of the digits 1 - 6 in the case of geometric grid points; blank or zero in the case of scalar points (Integer > 0)
Ai	Coefficient (Real; A must be non-zero)

- Remarks:
1. The first degree of freedom in the sequence is the dependent degree of freedom and must be unique for all equations of the set.
 2. MPCS constraints may be imposed only at the SOLVE step of substructuring in Phase 2. Therefore, referenced grid point components must exist in the final solution substructure.

3. The operation will constrain the degrees of freedom by the equation:

$$\sum A_i u_i = 0$$

where u_i is the displacement defined by NAMEi, Gi, and Ci.

4. Components may be connected within substructures and/or to separate substructures.
5. The dependent degree of freedom may not also be referenced on any SPCS, SPCS1, SPCSD, SPC, SPC1, OMIT, OMIT1 or SUPORT cards.
6. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
7. MPCS cards may be referenced by an MPCADD card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card NØLIN1 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = S T(u_j(t))$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN1	SID	GI	CI	S	GJ	CJ	T		
NØLIN1	21	3	4	2.1	3	1	6		

Field

Contents

SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number for GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
T	Identification number of a TABLEDi card (Integer > 0)

- Remarks:
1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
 2. Nonlinear loads may not be referenced on a DLØAD card.
 3. All coordinates referenced on NØLIN1 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card NØLIN2

Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = S u_j(t) u_k(t)$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN2	SID	GI	CI	S	GJ	CJ	GK	CK	
NØLIN2	14	2	1	2.9	2	1	2	1	

Field

Contents

SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
GK	Grid or scalar or extra point identification number (Integer > 0)
CK	Component number of GK a grid point (0 < Integer ≤ 6); blank or zero if GK is a scalar or extra point

- Remarks:
1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
 2. Nonlinear loads may not be referenced on a DLØAD card.
 3. All coordinates referenced on NØLIN2 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card NØLIN3

Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_j(t) = \begin{cases} S(u_j(t))^A, & u_j(t) > 0 \\ 0, & u_j(t) \leq 0 \end{cases}$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN3	SID	GI	CI	S	GJ	CJ	A		
NØLIN3	4	102		-6.1	2	5	-3.5		

Field

Contents

SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number for GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
A	Amplification factor (Real)

- Remarks:
1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
 2. Nonlinear loads may not be referenced on a DLØAD card.
 3. All coordinates referenced on NØLIN3 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card NØLIN4

Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = \begin{cases} -S(-u_j(t))^A, & u_j(t) < 0 \\ 0 & u_j(t) \geq 0 \end{cases}$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN4	SID	GI	CI	S	GJ	CJ	A		
NØLIN4	2	4	6	2.0	101		16.3		

Field

Contents

SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number for GI a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number for GJ a grid point (0 < Integer ≤ 6); blank or zero if GJ is a scalar or extra point
A	Amplification factor (Real)

- Remarks:
1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
 2. Nonlinear loads may not be referenced on a DLØAD card.
 3. All coordinates referenced on NØLIN4 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card ØMIT

Omitted Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to omit from the problem through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMIT	ID	C	ID	C	ID	C	ID	C	
ØMIT	16	2	23	3516			1	4	

Field

Contents

ID Grid or scalar point identification number (Integer > 0)

C Component number, zero or blank for scalar points, any unique combination of the digits 1-6 for grid points

Remarks: 1. Coordinates specified on ØMIT cards may not be specified on ØMIT1, ASET, ASET1, SUPØRT, SPC or SPC1 cards nor may they appear as dependent coordinates in multi-point constraint relations (MPC) or as permanent single-point constraints on GRID card.

2. As many as 24 coordinates may be omitted by a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card ØMIT1

Omitted Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to omit from the problem through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMIT1	C	G	G	G	G	G	G	G	abc
ØMIT1	3	2	1	3	10	9	6	5	ABC
+bc	G	G	G	-etc.-					
+BC	7	8							

Alternate Form

-etc.-

ØMIT1	C	ID1	"THRU"	ID2					
ØMIT1	0	17	THRU	109					

Field

Contents

C Component number (Any unique combination of the digits 1-6 (with no imbedded blanks) when point identification numbers are grid points; must be null or zero if point identification numbers are scalar points)

G, ID1, ID2 Grid or scalar point identification number (Integer > 0; ID1 < ID2)

- Remarks:
1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation (MPC card), nor may it be referenced on a SPC, SPC1, ØMIT, ASET, ASET1, or SUPØRT card or on a GRID card as permanent single-point constraints.
 2. If the alternate form is used, all of the grid (or scalar) points ID1 thru ID2 are assumed.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card ØMITAX

Axisymmetric Omitted Coordinate

Description: Defines coordinates that the user desires to omit from a model containing CCØNEAX, CTRAPAX or CTRIAAX elements through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMITAX	RID	HID	C	RID	HID	C			
ØMITAX	2	6	3	4	7	1			

Field

Contents

RID Ring identification number (Integer > 0)
HID Harmonic identification number (Integer ≥ 0)
C Component number (any unique combination of the digits 1-6)

- Remarks:**
1. This card is allowed if and only if an AXIC card is also present.
 2. Up to 12 coordinates may be omitted via this card.
 3. Coordinates appearing on ØMITAX cards may not appear on MPCAX, SUPAX or SPCAX cards.
 4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
 5. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.


NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PAER01 Aerodynamic Panel Property

Description: Gives properties for DOUBLET LATTICE method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PAER01	PID		X0	X1					
PAER01	1		.45	.95					

Field

Contents

PID Property identification number (referenced by CAER0), (unique Integer > 0).

X0 Center of pressure in fraction of box chord (Real), default X0 = 0.25.

X1 Downwash center in fraction of box chord (Real), default X1 = 0.75.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PARAM

Parameter

Description: Specifies values for parameters used in DMAP sequences (including rigid formats).

Format and Example :

1	2	3	4	5	6	7	8	9	10
PARAM	N	V1	V2						
PARAM	IRES	1							

Field

Contents

N Parameter name (one to eight alphanumeric characters, the first of which is alphabetic)

V1, V2 Parameter value based on parameter type as follows:

Type	V1	V2
Integer	Integer	Blank
Real, single-precision	Real	Blank
BCD	BCD	Blank
Real, double-precision	Double-precision	Blank
Complex, single-precision	Real	Real
Complex, double-precision	Double-precision	Double-precision

Remarks: 1. Only parameters for which assigned values are allowed may be given values via the PARAM card. Section 5 describes parameters as used in DMAP.

2. The following is a list of the parameters:

- a. GRDPNT - optional in all DISPLACEMENT and AERØ rigid formats. A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed. The value of the integer indicates the grid point to be used as a reference point. If the integer is zero (blank is not equivalent) or is not a defined grid point, the reference point is taken as the origin of the basic coordinate system. All fluid related masses are ignored. Additional details for the Grid Point Weight Generator are given in Section 5.5 of the Theoretical Manual. The following weight and balance information is automatically printed following the execution of the Grid Point Weight Generator.

- (1) Reference point.
- (2) Rigid body mass matrix $[M_0]$ relative to the reference point in the basic coordinate system.
- (3) Transformation matrix $[S]$ from basic coordinate system to principal mass axes.
- (4) Principal masses (mass) and associated centers of gravity (X-C.G., Y-C.G., Z-C.G.).
- (5) Inertia matrix $I(S)$ about the center of gravity relative to the principal mass axes.
- (6) Inertia matrix $I(Q)$ about the center of gravity relative to the principal inertia axes.
- (7) Transformation matrix $[Q]$ between S-axes and Q-axes.

NASTRAN DATA DECK

PARAM (Cont.)

- b. WTMASS - optional in all DISPLACEMENT and AERØ rigid formats. The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.
- c. IRES - optional in all DISPLACEMENT and HEAT statics problems (rigid formats 1, 2, 4, 5 and 6). A positive integer value of this parameter will cause the printing of the residual vectors following each execution of SSG3.
- d. LFREQ and HFREQ - required in all modal formulations of DISPLACEMENT and AERØ dynamics problems (rigid formats 10, 11 and 12) unless LMØDES is used. The real values of these parameters give the cyclic frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.
- e. LMØDES - required in all modal formulations of DISPLACEMENT and AERØ dynamics problems (rigid formats 10, 11 and 12) unless LFREQ and HRFEQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.
- f. G - optional in the direct formulation of all DISPLACEMENT dynamics problems (rigid formats 7, 8 and 9). The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems (See Section 9.3.3 of the Theoretical Manual). Not recommended for use in hydroelastic problems.
- g. W3 and W4 - optional in the direct formulation of DISPLACEMENT transient response problems (rigid format 9). The real values (radians/unit time) of these parameters are used as pivotal frequencies for uniform structural damping and element structural damping, respectively (See Section 9.3.3 of the Theoretical Manual). The parameter W3 should not be used for hydroelastic problems.
- h. MØDACC - optional in the modal formulation of frequency response (rigid format 11) and transient response (rigid format 12) problems. A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.
- i. CØUPMASS - optional in all DISPLACEMENT and AERØ rigid formats. A positive integer value of this parameter will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness. This option applies to both structural and nonstructural mass for the following elements: BAR, CØNRØD, QUAD1, QUAD2, RØD, TRIA1, TRIA2, TUBE. Since structural mass is not defined for the following list of elements, the option applies only to the nonstructural mass: QDPLT, TRBSC, TRPLT. A negative value causes the generation of lumped mass matrices (translational components only) for all the above elements. (This is the default). A zero value activates the following parameters described under j.
- j. CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional in all DISPLACEMENT and AERØ rigid formats. These parameters are active only if CØUPMASS=0. A positive value will cause the generation of coupled mass matrices for all elements of that particular type as shown by the following table:

Parameter	Element Types
CPBAR	BAR
CPRØD	RØD, CONRØD
CPQUAD1	QUAD1
CPQUAD2	QUAD2
CPTRIA1	TRIA1
CPTRIA2	TRIA2
CPTUBE	TUBE
CPQDPLT	QDPLT
CPTRPLT	TRPLT
CPTRBSC	TRBSC

A negative value (the default) for these parameters will cause the generation of the lumped mass matrices (translational components only) for these element types.

BULK DATA DECK

PARAM (Cont.)

- k. MAXIT - optional in nonlinear static HEAT transfer analysis (rigid format 3). The integer value of this parameter limits the maximum number of iterations. The default value is 4 iterations.
- l. EPSHT - optional in nonlinear static HEAT transfer analysis (rigid format 3). The real value of this parameter is used to test the convergence of the nonlinear heat transfer solution (see Section 8.4.1 of the Theoretical Manual). The default value is .001.
- m. TABS - optional in nonlinear static (rigid format 3) and transient (rigid format 9) HEAT transfer analysis. The real value of this parameter is the absolute reference temperature. The default value is 0.0.
- n. SIGMA - optional in nonlinear static (rigid format 3) and transient (rigid format 9) HEAT transfer analysis. The real value of this parameter is the Stefan-Boltzman constant. The default value is 0.0.
- o. BETA - optional in transient HEAT transfer analysis (rigid format 9). The real value of this parameter is used as a factor in the integration algorithm (see Section 8.4.2 of the Theoretical Manual). The default value is 0.55.
- p. RADLIN - optional in transient HEAT transfer analysis (rigid format 9). A positive integer value of this parameter causes some of the radiation effects to be linearized (see Equation 2, Section 8.4.2 of the Theoretical Manual). The default value is -1.
- q. BETAD - optional in static analysis with differential stiffness (rigid format 4). The integer value of this parameter is the number of iterations allowed for computing the load correction in the inner (load) loop before shifting to the outer (stiffness) loop which adjusts the differential stiffness. The default value is 4 iterations.
- r. NT - optional in static analysis with differential stiffness (rigid format 4). The integer value of this parameter limits the cumulative number of iterations in both loops. The default value is 10 iterations.
- s. EPSI0 - optional in static analysis with differential stiffness (rigid format 4). The real value of this parameter is used to test the convergence of iterated differential stiffness. The default value is 10^{-5} .
- t. CTYPE - required in cyclic symmetry analysis (rigid formats 14 and 15). The BCD value of this parameter defines the type of cyclic symmetry as follows:
 - (1) R0T - rotational symmetry
 - (2) DRL - dihedral symmetry, using right and left halves
 - (3) DSA - dihedral symmetry, using symmetric and antisymmetric components.
- u. NESGS - required in cyclic symmetry analysis (rigid formats 14 and 15). The integer value of this parameter is the number of identical segments in the structural model.
- v. NLOAD - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter is the number of static loading conditions. The default value is 1.
- w. CYCI0 - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter specifies the form of the input and output data. A value of +1 is used to specify physical segment representation, and a value of -1 for cyclic transform representation. The default value is +1.
- x. CYCSEQ - optional in cyclic symmetry analysis (rigid formats 14 and 15). The integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.

NASTRAN DATA DECK

PARAM (Cont.)

- y. KMAX - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter specifies the maximum value of the harmonic index. The default value is ALL which is NSEGS/2 for NSEGS even and (NSEGS-1)/2 for NSEGS odd.
- z. KINDEX - required in normal modes with cyclic symmetry (rigid format 15). The integer value of this parameter specifies a single value of the harmonic index.
- aa. NØDJE - optional in modal flutter analysis. A positive integer of this parameter indicates user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1.
- ab. P1,P2 and P3 - required in modal flutter analysis when using NØDJE parameter. See Section 5.3.2 for tape operation parameters required by INPUTT2 module. The defaults for P1,P2 and P3 are -1,11 and TAPEID, respectively.
- ac. VREF - optional in modal flutter analysis. Velocities are divided by the real value of this parameter to convert units or to compute flutter indices. The default value is 1.0.
- ad. PRINT - optional in modal flutter analysis. The BCD value, NØ, of this parameter will suppress the automatic printing of the flutter summary for the K method. The default value is YES.

BULK DATA DECK

Input Data Card PBAR

Simple Beam Property

Description: Defines the properties of a simple beam (bar) which is used to create bar elements via the CBAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PBAR	PID	MID	A	I1	I2	J	NSM		abc
PBAR	39	6	2.9		5.97				123
+bc	C1	C2	D1	D2	E1	E2	F1	F2	def
+23			2.0	4.0					
+ef	K1	K2	I12						

Field

Contents

PID Property identification number (Integer > 0)
MID Material identification number (Integer > 0)
A Area of bar cross-section (Real)
I1, I2, I12 Area moments of inertia (Real, $I_1 I_2 \geq I_{12}^2$)
J Torsional constant (Real)
NSM Nonstructural mass per unit length (Real)
K1, K2 Area factor for shear (Real)
Ci, Di, Ei, Fi Stress recovery coefficients (Real)

Remarks: 1. For structural problems, PBAR cards may only reference MAT1 material cards.
2. See Section 1.3.2 for a discussion of bar element geometry.
3. For heat transfer problems, PBAR cards may only reference MAT4 or MAT5 material cards.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PCØNEAX

Conical Shell Element Property

Description: Defines the properties of a conical shell element described on a CCØNEAX card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PCØNEAX	ID	MID1	T1	MID2	I	MID3	T2	NSM	+abc
PCØNEAX	2	4	1.0	6	16.3	8	2.1	0.5	+1
+abc	Z1	Z2	PHI1	PHI2	PHI3	PHI4	PHI5	PHI6	+def
+1	0.001	-0.002	23.6	42.9					+2
+def	PHI7	PHI8	PHI9	PHI10	PHI11	PHI12	PHI13	PHI14	
+2									

Field

Contents

ID Property identification number (Unique Integer > 0)
MIDI Material identification number for membrane, bending, and transverse shear (Integer ≥ 0)
T1,T2 Membrane thickness and transverse shear thickness (Real > 0.0 if MIDI $\neq 0$)
I Moment of Inertia per unit width (Real)
NSM Nonstructural mass per unit area (Real)
Z1, Z2 Fiber distances for stress recovery (Real)
PHIi Azimuthal coordinates (in degrees) for stress recovery (Real)

Remarks:

1. This card is allowed if and only if a AXIC card is also present.
2. PCØNEAX cards may only reference MAT1 material cards.
3. If either MID1 = 0 or blank or T1 = 0.0 or blank, then both must be zero or blank.
4. If either MID2 = 0 or blank or I = 0.0 or blank, then both must be zero or blank.
5. If either MID3 = 0 or blank or T2 = 0.0 or blank, then both must be zero or blank.
6. A maximum of 14 azimuthal coordinates for stress recovery may be specified. An error will be detected if more than two (2) continuation cards appear.
7. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PDAMP

Scalar Damper Property

Description: Used to define the damping value of a scalar damper element which is defined by means of the CDAMP1 or CDAMP3 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PDAMP	PID	B	PID	B	PID	B	PID	B	
PDAMP	14	-2.3	2	6.1					

Field

Contents

PID Property identification number (Integer > 0)
 B Value of scalar damper (Real)

- Remarks:
1. This card defines a damper value. The user is cautioned to be careful when using negative damper values. Damper values are defined directly on the CDAMP2 and CDAMP4 cards. A structural viscous damper, CVISC, may also be used for geometric grid points.
 2. Up to four damper properties may be defined on a single card.
 3. For a discussion of scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PDUMi

Dummy Element Property

Description: Defines the properties of a dummy element ($1 \leq i \leq 9$). Referenced by the CDUMi card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PDUMi	PID	MID	A1	A2			-etc.-		abc
PDUM3	108	2	2.4	9.6	1.E4	15.		3.5	ABC
+bc		-etc.-	AN						
+BC	5		2						

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
A1...AN	Additional entries (Real or Integer)

Remarks: The additional entries are defined in the user written element routines.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PELAS

Scalar Elastic Property

Description: Used to define the stiffness, damping coefficient, and stress coefficient of a scalar elastic element (spring) by means of the CELAS1 or CELAS3 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PELAS	PID	K	GE	S	PID	K	GE	S	
PELAS	7	4.29	0.06	7.92	27	2.17	0.0032		

Field

Contents

PID	Property identification number (Integer > 0)
K	Elastic property value (Real)
GE	Damping coefficient, g_e (Real)
S	Stress coefficient (Real)

- Remarks:
1. The user is cautioned to be careful using negative spring values. (Values are defined directly on some of the CELASi card types.)
 2. One or two elastic spring properties may be defined on a single card.
 3. For a discussion of scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PHBDY

Property of Heat Boundary Element

Description: Defines the properties of the HBDY element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PHBDY	PID	MID	AF	E	ALPHA	R1	R2		
PHBDY	100	103	300.	.79					

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer ≥ 0 or blank), used for convective film coefficient and thermal capacity.
AF	Area factor (Real ≥ 0.0 or blank). Used only for HBDY types PØINT, LINE, and ELCYL.
E	Emissivity ($0.0 \leq \text{Real} \leq 1.0$ or blank). Used only for radiation calculations.
ALPHA	Absorbitivity ($0.0 \leq \text{Real} \leq 1.0$ or blank). Used only for thermal vector flux calculations, default value is E.
R1,R2	"Radii" of elliptic cylinder. Used for HBDY type "ELCYL". See the HBDY element description. (Real)

Remarks:

1. The referenced material Id must be on a MAT4 card. The card defines the convective film coefficient and thermal capacity per unit area. If no material is referenced the element convection and heat capacity are zero.
2. The area factor AF is used to determine the effective area. For a "PØINT", AF = area; for "LINE" or "ELCYL", AF = effective width where area = AF·length. The effective area is automatically calculated for other HBDY types.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PIHEX

Isoparametric Hexahedron Property

Description: Defines the properties of an isoparametric solid element, including a material reference and the number of integration points. Referenced by the CIHEX1, CIHEX2, and CIHEX3 cards.

Format and Example:

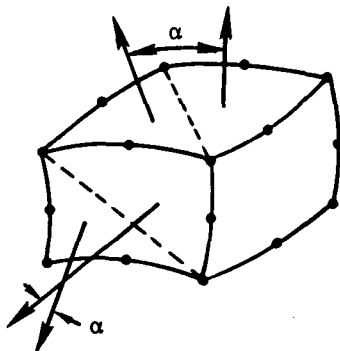
1	2	3	4	5	6	7	8	9	10
PIHEX	PID	MID	CID	NIP	AR	ALFA	BETA		
PIHEX	15	3		3			5.0		

Field

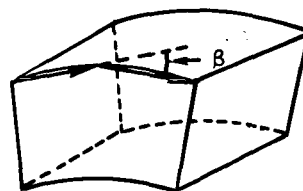
Contents

PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
CID	Identification number of the coordinate system in which the material referenced by MID is defined (Integer ≥ 0 or blank)
NIP	Number of integration points along each edge of the element (Integer = 2, 3, 4 or blank)
AR	Maximum aspect ratio (ratio of longest to shortest edge) of the element (Real > 1.0 or blank)
ALFA	Maximum angle in degrees between the normals of two subtriangles comprising a quadrilateral face (Real, $0.0 \leq \text{ALFA} \leq 180.0$, or blank)
BETA	Maximum angle in degrees between the vector connecting a corner point to an adjacent midside point and the vector connecting that midside point and the other midside or corner point (Real, $0.0 \leq \text{BETA} \leq 180.0$, or blank)

Examples of Field Definitions:



Example of ALFA



Example of BETA

NASTRAN DATA DECK

PIHEX (Cont.)

- Remarks:
1. All PIHEX cards must have unique identification numbers.
 2. CID is not used for isotropic materials.
 3. The default for CID is the basic coordinate system.
 4. The default for NIP is 2 for IHEX1 and 3 for IHEX2 and IEHX3.
 5. AR, ALFA, and BETA are used for checking the geometry of the element. The defaults are:

	AR	ALFA (degrees)	BETA (degrees)
CIHEX1	5.0	45.0	--
CIHEX2	10.0	45.0	45.0
CIHEX3	15.0	45.0	45.0

BULK DATA DECK

Input Data Card PLFACT

Piecewise Linear Analysis Factor Definition Card

Description: Defines scale factors for Piecewise Linear Analysis loading.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLFACT	SID	B1	B2	B3	B4	B5	B6	B7	+abc
PLFACT	6	0.2	0.3	0.4	0.5	0.6	0.7	0.8	ABC
+abc	B8	B9	-etc.-						
+BC	0.9	1.0							

Field

Contents

SID Unique set identification number (Integer > 0)
 Bi Loading factor (Real)

- Remarks:
1. The remainder of the physical card containing the last entry must be null.
 2. At any stage of the Piecewise Linear Analysis, the accumulated load is given by

$$\{P_i\} = B_i\{P\}$$

where $\{P\}$ is the total load defined in the usual way.

Example: If it were desired to load the structure in ten equally spaced load increments then set

$$B_i = 0.1 \cdot i ; i = 1, 10$$

3. Normally, the B_i form a monotonically increasing sequence. A singular stiffness matrix will result if $B_i = B_{i-1}$.
4. At least two factors must be defined.
5. Piecewise Linear Analysis factor sets must be selected in the Case Control Deck (PLCØEFF=SID) to be used by NASTRAN.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PLIMIT Property Optimization Limits

Description: Defines the maximum and minimum limits for ratio of new property to original property.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLIMIT	ELTYP	KMIN	KMAX	PID1	PID2	PID3	PID4	PID5	+abc
PLIMIT	RØD	.01	1.5	1	3	5	4	2	+ABC
+bc	PID6	-etc.-							
+BC		-etc.-							

Alternate form:

PLIMIT	ELTYP	KMIN	KMAX	PID1	"THRU"	PIDi			
PLIMIT	ALL	.001	0.05	30	"THRU"	36			

Field

Contents

ELTYP	One of the following element types: RØD, TUBE, BAR, TRMEM, QDMEM, TRPLT, QDPLT, TRBSC, TRIA1, QUAD1, TRIA2, QUAD2, SHEAR, or ALL or blank.
KMIN	Minimum property ratio (Real > 0.0)
KMAX	Maximum property ratio (Real > KMIN or = 0.0)
PIDn	List of property identification numbers associated with KMIN and/or KMAX (Integer > 0)

- Remarks:
1. This card is not required (Default KMIN = KMAX = 0.0 for ALL elements).
 2. All PID values must be unique for each element type.
 3. All elements with the same property identification number in the output stress data block, ØES1, have these limits applied if ALL is specified.
 4. Property entries optimized depend on the element type and material stress limits. Only nonzero properties with nonzero stress limits are optimized.
 5. If KMAX = 0.0, no limit is placed on the maximum change.
 6. If ELTYP is blank, ALL is assumed.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PLØAD Static Pressure Load

Description: Defines a static pressure load.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØAD	SID	P	G1	G2	G3	G4			
PLØAD	1	-4.0	16	32	11				

Field

Contents

SID Load set identification number (Integer > 0)
P Pressure (Real)
G1,G2,G3,G4 Grid point identification numbers (Integer > 0; G4 may be zero)

Remarks: 1. Grid points must be unique and noncollinear.
2. If four grid points are given, four triangles are formed and half of P is applied to each one. For each triangle the direction is defined by

$$+(\vec{r}_{12} \times \vec{r}_{13})$$

where \vec{r}_{ij} is the vector from Gi to Gj.

3. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PLØAD2

Pressure Load

Description: Defines a uniform static pressure load applied to two-dimensional elements. Only QUAD1, QUAD2, QDMEM, QDMEM1, QDMEM2, QDPLT, SHEAR, TRBSC, TRIA1, TRIA2, TRMEM, TRPLT or TWIST elements may have a pressure load applied to them via this card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØAD2	SID	P	EID	EID	EID	EID	EID	EID	
PLØAD2	21	-3.6		4	16		2		

Alternate Form

PLØAD2	SID	P	EID1	"THRU"	EID2				
PLØAD2	1	30.4	16	THRU	48				

Field

Contents

SID	Load set identification number (Integer > 0)
P	Pressure value (Real)
EID EID1 EID2	Element identification number (Integer > 0; EID1 < EID2)

- Remarks:
1. EID must be 0 or blank for omitted entries.
 2. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
 3. At least one positive EID must be present on each PLØAD2 card.
 4. If the alternate form is used, all elements EID1 thru EID2 must be two-dimensional.
 5. The pressure load is computed for each element as if the grid points to which the element is connected were specified on a PLØAD card. The grid point sequence specified on the element connection card is assumed for the purpose of computing pressure loads.
 6. All elements referenced must exist.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PLØAD3

Pressure Load on a Face of an Isoparametric Element

Description: Defines a uniform static pressure load applied to a surface of an isoparametric hexahedron element only.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØAD3	SID	P	EID1	G11	G12	EID2	G21	G22	
PLØAD3	3	-15.1	15	7	25	16	117	135	

Field

Contents

SID	Load set identification number (Integer > 0)
P	Pressure value (Real, force per unit area)
EID1	} Element identification number (Integer > 0)
EID2	
G11, G12	} Grid point identification number of two grid points at diagonally opposite corners of the face on which the pressure acts (Integers > 0)
G21, G22	

- Remarks:
1. Load sets must be selected in the Case Control Deck (LØAD = SID) to be used by NASTRAN.
 2. At least one EID must be present on each PLØAD3 card.
 3. All elements referenced must exist.
 4. Computations consider the pressure to act positive outward on specified face of element.

NASTRAN DATA DECK

2.4-198b (12/31/74)


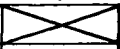
BULK DATA DECK

Input Data Card PLØTEL

Dummy Element Definition

Description: Defines a dummy one-dimensional element for use in plotting. This element is not used in the model during any of the solution phases of a problem. It is used to simplify plotting of structures with large numbers of collinear grid points where the plotting of each one along with the elements connecting them would result in a confusing plot. The use of this "element" is entirely the responsibility of the user.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLØTEL	EID	G1	G2		EID	G1	G2		
PLØTEL	29	35	16						

Field

Contents

EID Element identification number (Integer > 0)
 G1, G2 Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. One or two PLØTEL elements may be defined on a single card.

NASTRAN DATA DECK

NASTRAN DATA DECK

Input Data Card PMASS

Scalar Mass Property

Description: Used to define the mass value of a scalar mass element which is defined by means of the CMASS1 or CMASS3 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PMASS	PID	M	PID	M	PID	M	PID	M	
PMASS	7	4.29	6	13.2					

Field

Contents

PID Property identification number (Integer > 0)
M Value of scalar mass (Real)

- Remarks:
1. This card defines a mass value. The user is cautioned to be careful when using negative mass values. (Values are defined directly on some of the CMASSi card types.)
 2. Up to four mass properties may be defined by this card.
 3. For a discussion of scalar elements, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PØINTAX

Axisymmetric Point

Description: Defines the location of a point on an axisymmetric ring at which loads may be applied via the FØRCE, FØRCEAX, MØMENT or MØMAX cards and at which displacements may be requested. These points are not subject to constraints via MPCAX, SPCAX, or ØMITAX cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PØINTAX	ID	RID	PHI						
PØINTAX	2	3	30.0						

Field

Contents

ID Point identification number (Unique Integer > 0)
 RID Identification number of a RINGAX card (Integer > 0)
 PHI Azimuthal angle in degrees (Real)

- Remarks:
1. This card is allowed if and only if an AXIC card is also present.
 2. PØINTAX identification numbers must be unique with respect to all other PØINTAX, RINGAX and SECTAX identification numbers.
 3. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
 4. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PØPT

Property Optimization Parameter

Description: Defines the basic parameters and existence of a property optimization analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PØPT	MAX	EPS	GAMA	PRINT	PUNCH				
PØPT	2	1.0E-3	0.9	2	NØ				

Field

Contents

MAX	• Maximum number of iterations on property values (Integer > 0)
EPS	Convergence criteria for property value. If zero, no convergence check (Real ≥ 0.0)
GAMA	Iteration factor (Default = 1.0) (Real > 0.0)
PRINT	Print control for property parameters and ØFP. Printout occurs every Ith loop. The first and last loops are always printed (Integer > 0)
PUNCH	Property card punch option. If YES, properties that were optimized are punched (BCD, "YES" or "NO")

- Remarks:
1. Only one PØPT card is allowed.
 2. All subcases will be analyzed MAX+1 times unless all properties converge.
 3. Property convergence is defined by

$$\frac{|\sigma - \sigma_l|}{\sigma_l} < EPS$$

where σ is the maximum stress and σ_l is the appropriate stress limit on the material card.

4. Stress recovery must be requested for one of the following elements: RØD, TUBE, BAR, TRMEM, QDMEM, TRPLT, QDPLT, TRBSC, TRIA1, QUAD1, TRIA2, QUAD2, or SHEAR. In addition, the material card must have stress limits defined.
5. Property cards are always printed for the last iteration.
6. The property entry optimized depends on the element type and the material stress limits (see Section 1.13).

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PQDMEM

Quadrilateral Membrane Property

Description: Used to define the properties of a quadrilateral membrane. Referenced by the CQDMEM card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDMEM	PID	MID	T	NSM	PID	MID	T	NSM	
PQDMEM	235	2	0.5	0.0					

Field

Contents

PID Property identification number (Integer > 0)
MID Material identification number (Integer > 0)
T Thickness of membrane (Real > 0.0)
NSM Nonstructural mass per unit area (Real)

Remarks: 1. All PQDMEM cards must have unique property identification numbers.
2. One or two quadrilateral membrane properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PQDMEM1

Isoparametric Quadrilateral Membrane Property

Description: Used to define the properties of an isoparametric quadrilateral membrane. Referenced by the CQDMEM1 card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDMEM1	PID	MID	T	NSM	PID	MID	T	NSM	
PQDMEM1	235	2	0.5	0.0					

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of membrane (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

- Remarks:
1. All PQDMEM1 cards must have unique property identification numbers.
 2. One or two isoparametric quadrilateral membrane properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PQDMEM2

Quadrilateral Membrane Property

Description: Used to define the properties of a quadrilateral membrane. Referenced by the CQDMEM2 card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDMEM2	PID	MID	T	NSM	PID	MID	T	NSM	
PQDMEM2	235	2	0.5	0.0					

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of membrane (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

- Remarks:
1. All PQDMEM2 cards must have unique property identification numbers.
 2. One or two quadrilateral membrane properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PQDPLT Quadrilateral Plate Property

Description: Used to define the bending properties of a quadrilateral plate element. Referenced by the CQDPLT card. No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQDPLT	PID	MID1	I	MID2	T	NSM	Z1	Z2	
PQDPLT	16	23	4.29	16	2.63	1.982	0.05	-0.05	

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
I	Bending area moment of inertia per unit width (Real)
MID2	Material identification number for transverse shear (Integer \geq 0)
T	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress computation, positive according to the right-hand sequences defined on the CQDPLT card (Real)

- Remarks:
1. All PQDPLT cards must have unique property identification numbers.
 2. If T is zero, the element is assumed to be rigid in transverse shear.
 3. No structural mass is generated for this element.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PQUAD1

General Quadrilateral Element Property

Description: Defines the properties of a general quadrilateral element of the structural model, including bending, membrane, and transverse shear effects. Referenced by the CQUAD1 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQUAD1	PID	MID1	T1	MID2	I	MID3	T3	NSM	abc
PQUAD1	32	16	2.98	9	6.45	16	5.29	6.32	WXYZ1
+bc	Z1	Z2							
+XYZ1	0.09	-0.06							

Field

Contents

PID	Property identification number (Integer > 0)
MID1	Material identification number for membrane (Integer ≥ 0)
T1	Membrane thickness (Real)
MID2	Material identification number for bending (Integer ≥ 0)
I	Area moment of inertia per unit width (Real)
MID3	Material identification number for transverse shear (Integer ≥ 0)
T3	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress computation, positive according to the right-hand sequence defined on the CQUAD1 card (Real)

- Remarks:
1. All PQUAD1 cards must have unique property identification numbers.
 2. If T3 is zero, the element is assumed to be rigid in transverse shear.
 3. The membrane thickness, T1, is used to compute the structural mass for this element.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PQUAD2

Homogeneous Quadrilateral Property

Description : Defines the properties of a homogeneous quadrilateral element of the structural model, including bending, membrane and transverse shear effects. Referenced by the CQUAD2 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PQUAD2	PID	MID	T	NSM	PID	MID	T	NSM	
PQUAD2	32	16	2.98	9.0	45	16	5.29	6.32	

Field

Contents

PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

- Remarks:
1. All PQUAD2 cards must have unique identification numbers.
 2. The thickness used to compute membrane and transverse shear properties is T.
 3. The area moment of inertia per unit width used to compute the bending stiffness is $T^3/12$.
 4. Outer fiber distances of $\pm T/2$ are assumed.
 5. One or two homogeneous quadrilateral properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PRESAX

Axisymmetric Pressure Load

Description: Defines the static pressure loading for a model containing CCONEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PRESAX	SID	P	RID1	RID2	PHI1	PHI2			
PRESAX	3	7.92	4	3	20.6	31.4			

Field

Contents

SID Load set identification number (Integer > 0)

P Pressure value (Real)

RID1 {
RID2 { Ring identification numbers (see RINGAX card) (Integer > 0)

PHI1 {
PHI2 { Azimuthal angles in degrees (Real)

Remarks: 1. This card is allowed if and only if an AXIC card is also present.

2. Load sets must be selected in the Case Control Deck (LOAD=SID) in order to be used by NASTRAN.
3. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
4. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

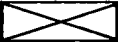
BULK DATA DECK

Input Data Card PRESPT

Fluid Pressure Point

Description: Defines the location of pressure points in the fluid for recovery of pressure data.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PRESPT	IDF		IDP	ϕ	IDP	ϕ	IDP	ϕ	
PRESPT	14		141	0.0			142	90.0	

Field

Contents

IDF Fluid point (RINGFL) identification number (Integer > 0)
 IDP Unique pressure point identification number (Integer > 0)
 ϕ Azimuthal position on fluid point, referenced by IDF, in Fluid Coordinate System (Real)

- Remarks:
1. This card is allowed only if an AXIF card is also present.
 2. All pressure point identification numbers must be unique with respect to other scalar, structural and fluid points.
 3. The pressure points are used primarily for the identification of output data. They may also be used as points at which to measure pressure for input to control devices (see User's Manual, Section 1.7).
 4. One, two or three pressure points may be defined per card.
 5. Output requests for velocity and acceleration of these degrees of freedom will result in derivatives of pressure with respect to time.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PRØD Rod Property

Description: Defines the properties of a rod which is referenced by the CRØD card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PRØD	PID	MID	A	J	C	NSM			
PRØD	17	23	42.6	17.92	4.236	0.5			

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
A	Area of rod (Real)
J	Torsional constant (Real)
C	Coefficient to determine torsional stress (Real)
NSM	Nonstructural mass per unit length (Real)

- Remarks:
1. PRØD cards must all have unique property identification numbers.
 2. For structural problems, PRØD cards may only reference MAT1 material cards.
 3. For heat transfer problems, PRØD cards may only reference MAT4 or MAT5 cards.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PSHEAR

Shear Panel Property

Description: Defines the elastic properties of a shear panel. Referenced by the CSHEAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PSHEAR	PID	MID	T	NSM	PID	MID	T	NSM	
PSHEAR	13	2	4.9	16.2	14	6	4.9	14.7	

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of shear panel (Real \neq 0.0)
NSM	Nonstructural mass per unit area (Real)

- Remarks:
1. All PSHEAR cards must have unique identification numbers.
 2. PSHEAR cards may only reference MAT1 material cards.
 3. One or two shear panel properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTØRDRG

Toroidal Ring Property

Description: Used to define membrane and flexure (bending) properties of a toroidal ring element. Referenced by the CTØRDRG card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTØRDRG	PID	MID	TM	TF	PID	MID	TM	TF	
PTØRDRG	2	4	0.1	0.15					

Field

Contents

PID Property identification number (Integer > 0)
MID Material identification number (Integer > 0)
TM Thickness for membrane (Real > 0.0)
TF Thickness for flexure (Real)

- Remarks:
1. All PTØRDRG cards must have unique property identification numbers.
 2. The material identification number MID must reference only a MAT1 or MAT3 card.
 3. One or two toroidal ring properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTRAPAX Triangular Ring Element Property

Description: Defines the properties of an axisymmetric trapezoidal cross-section ring element referenced by the CTRAPAX card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRAPAX	PID		MID	PHI1	PHI2	PHI3	PHI4	PHI5	+abc
PTRAPAX	5		15	0.0	5.0	6.0	7.0	8.0	+N1
+abc	PHI6	PHI7	PHI8	PHI9	PHI10	PHI11	PHI12	PHI13	+def
+N1	9.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	+2
+def	PHI14								
+N2	45.0								

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0).
MID	Material identification number (Integer > 0).
PHIi	Azimuthal coordinates (in degrees) for stress recovery (Real).

Remarks :

1. All PTRAPAX cards must have unique property identification numbers.
2. This card is allowed if and only if an AXIC card is also present.
3. PTRAPAX card may reference MAT1 or MAT3 material cards.
4. A maximum of 14 azimuthal coordinates for stress recovery may be specified.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTRBSC

Basic Bending Triangle Property

Description: Defines basic bending triangle (TRBSC) properties. Referenced by the CTRBSC card.
No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRBSC	PID	MID1	I	MID2	T	NSM	Z1	Z2	
PTRBSC	3	17	6.29	4	16.	1.982	0.05	-0.05	

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
I	Bending area moment of inertia per unit width (Real)
MID2	Material identification number for transverse shear (Integer ≥ 0)
T	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for shear computation, positive according to the right-hand sequence defined in the CTRBSC card (Real)

- Remarks:
1. All PTRBSC cards must have unique property identification numbers.
 2. If T is zero, the element is assumed to be rigid in transverse shear.
 3. No structural mass is generated by this element.


NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTRIAAX Triangular Ring Element Property

Description: Defines the properties of an axisymmetric triangular cross-section ring element referenced by the CTRIAAX card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRIAAX	PID		MID	PHI1	PHI2	PHI3	PHI4	PHI5	+abc
PTRIAAX	5		15	0.0	5.0	6.0	7.0	8.0	+N1
+abc	PHI6	PHI7	PHI8	PHI9	PHI10	PHI11	PHI12	PHI13	+def
+N1	9.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	+N2
+def	PHI14								
+N2	45.0								

Field

Contents

PID	Property identification number (Integer > 0).
MID	Material identification number (Integer > 0).
PHIi	Azimuthal coordinates (in degrees) for stress recovery (Real).

Remarks:

1. All PTRIAAX cards must have unique property identification numbers.
2. This card is allowed if and only if an AXIC card is also present.
3. PTRIAAX card may reference MAT1 or MAT3 material cards.
4. A maximum of 14 azimuthal coordinates for stress recovery may be specified.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTRIA1

General Triangular Element Property

Description: Defines the properties of a general triangular element of the structural model, including bending, membrane and transverse shear effects. Referenced by the CTRIA1 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRIA1	PID	MID1	T1	MID2	I	MID3	T3	NSM	abc
PTRIA1	32	16	2.98	9	6.45	16	5.29	6.32	QED
+bc	Z1	Z2							
+ED									

Field

Contents

PID	Property identification number (Integer > 0)
MID1	Material identification number for membrane (Integer ≥ 0)
T1	Membrane thickness (Real)
MID2	Material identification number for bending (Integer ≥ 0)
I	Area of moment of inertia per unit width (Real)
MID3	Bending material identification number for transverse shear (Integer ≥ 0)
T3	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress calculations, positive according to the right-hand sequence defined on the CTRIA1 card (Real)

- Remarks:
1. All PTRIA1 cards must have unique property identification numbers.
 2. If T3 is zero, the element is assumed to be rigid in transverse shear.
 3. The membrane thickness, T1, is used to compute the structural mass for this element.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTRIA2

Homogeneous Triangular Element Property

Description: Defines the properties of a homogeneous triangular element of the structural model, including membrane, bending and transverse shear effects. Referenced by the CTRIA2 card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRIA2	PID	MID	T	NSM	PID	MID	T	NSM	
PTRIA2	2	16	3.92	14.7	6	16	2.96		

Field

Contents

PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

- Remarks:
1. All PTRIA2 cards must have unique identification numbers.
 2. The thickness used to compute the membrane and transverse shear properties is T.
 3. The area moment of inertia per unit width used to compute the bending stiffness is $T^3/12$.
 4. Outer fiber distances of $\pm T/2$ are assumed.
 5. One or two homogeneous triangular element properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTRMEM Triangular Membrane Property

Description: Used to define the properties of a triangular membrane element. Referenced by the CTRMEM card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRMEM	PID	MID	T	NSM	PID	MID	T	NSM	
PTRMEM	17	23	4.25	0.2					

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Membrane thickness (Real > 0.0)
NSM	Nonstructural mass per unit area (Real)

- Remarks:
1. All PTRMEM cards must have unique property identification numbers.
 2. One or two triangular membrane properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTRPLT Triangular Plate Property

Description: Used to define the bending properties of a triangular plate element. Referenced by the CTRPLT card. No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRPLT	PID	MID1	I	MID2	T	NSM	Z1	Z2	
PTRPLT	17	26	4.29	16	3.9-4	2.634			

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
I	Bending area moment of inertia per unit width (Real)
MID2	Material identification number for transverse shear (Integer ≥ 0)
T	Transverse shear thickness (Real)
NSM	Nonstructural mass per unit area (Real)
Z1, Z2	Fiber distances for stress computation, positive according to the right-hand sequence defined on the CTRPLT card (Real)

- Remarks:
1. All PTRPLT cards must have unique property identification numbers.
 2. If T is zero, the element is assumed to be rigid in transverse shear.
 3. No structural mass is generated by this element.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTUBE Tube Property

Description: Defines the properties of a thin-walled cylindrical tube element. Referenced by the CTUBE card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTUBE	PID	MID	ØD	T	NSM				
PTUBE	2	6	6.29	0.25					

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
ØD	Outside diameter of tube (Real > 0.0)
T	Thickness of tube (Real; $T \leq 1/2 \text{ } \text{ØD}$)
NSM	Nonstructural mass per unit length (Real)

- Remarks:
1. If T is zero, a solid circular rod is assumed.
 2. PTUBE cards must all have unique property identification numbers.
 3. For structural problems, PTUBE cards may only reference MAT1 material cards.
 4. For heat transfer problems, PTUBE cards may only reference MAT4 or MAT5 material cards.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PTWIST

Twist Panel Property

Description: Defines the elastic properties of a twist panel element. Referenced by the CTWIST card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTWIST	PID	MID	T	NSM	PID	MID	T	NSM	
PTWIST	4	6	2.3	9.4	5	6	1.6		

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
T	Thickness of twist panel (Real \neq 0.0)
NSM	Nonstructural mass per unit area (Real)

- Remarks:
1. All PTWIST cards must have unique identification numbers.
 2. PTWIST cards may only reference MAT1 material cards.
 3. One or two twist panel properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card PVISC Viscous Element Property

Description: Defines the viscous properties of a one-dimensional viscous element which is used to create viscous elements by means of the CVISC card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PVISC	PID	C1	C2		PID	C1	C2		
PVISC	3	6.2	3.94						

<u>Field</u>	<u>Contents</u>
PID	Property identification number (Integer > 0)
C1, C2	Viscous coefficients for extension and rotation (Real)

- Remarks:
1. Used for both extensional and rotational viscous elements.
 2. Has meaning for dynamics problems only.
 3. Viscous properties are material independent; in particular, they are temperature-independent.
 4. One or two viscous element properties may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card QBDY1 Boundary Heat Flux Load

Description: Defines a uniform heat flux into HBDY elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QBDY1	SID	Q0	EID1	EID2	EID3	EID4	EID5	EID6	abc
QBDY1	109	1.-5	721						ABC
+bc	EID7	-etc.-							def
+BC									

-etc.-

Field

Contents

SID Load set identification number (Integer > 0)
 Q0 Heat flux into element (Real)
 EID_i HBDY elements (Integer > 0 or "THRU")

Remarks:

1. QBDY1 cards must be selected in Case Control (LØAD = SID) to be used in statics. The total power into an element is given by the equation:

$$P_{in} = (\text{Effective area}) \cdot Q0.$$

2. QBDY1 cards must be referenced on a TLØAD card for use in transient. The total power into an element is given by the equation:

$$P_{in}(t) = (\text{Effective area}) \cdot Q0 \cdot F(t-\tau),$$

where the function of time, $F(t-\tau)$, is specified on a TLØAD1 or TLØAD2 card.

3. Q0 is positive for heat input.
4. If a sequential list of elements is desired, fields 4, 5, and 6 may specify the first element, the BCD string "THRU", and the last element. No subsequent data is allowed with this option.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card QBDY2

Boundary Heat Flux Load

Description: Defines grid point heat flux into an HBDY element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QBDY2	SID	EID	Q01	Q02	Q03	Q04			
QBDY2	109	721	1.-5	1.-5	2.-5	2.-5			

Field

Contents

SID Load set identification number (Integer > 0)
 EID Identification number of an HBDY element (Integer > 0)
 Q0i Heat flux at the i^{th} grid point on the referenced HBDY element (Real or blank)

Remarks:

1. QBDY2 cards must be selected in Case Control (LØAD = SID) to be used in statics. The total power into each point, i , on an element is given by

$$P_i = \text{AREA}_i \cdot Q0_i.$$

2. QBDY2 cards must be referenced on a TLØAD card for use in transient. All connected grid points will have the same time function, but may have individual delays. The total power into each point, i , or an element is given by

$$P_i(t) = \text{AREA}_i \cdot Q0_i \cdot F(t - \tau_i),$$

where $F(t - \tau_i)$ is a function of time specified on a TLØAD1 or TLØAD2 card.

3. $Q0_i$ is positive for heat flux input to the element.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card QHBDY

Boundary Heat Flux Load

Description: Defines a uniform heat flux into a set of grid points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QHBDY	SID	FLAG	Q0	AF	G1	G2	G3	G4	
QHBDY	120	LINE	1.5+3	.75	13	15			

Field

Contents

SID Load set identification number (Integer > 0)

FLAG Type of area involved (must be one of the following "P0INT," "LINE," "REV," "AREA3," "AREA4")

Q0 Heat flux into an area (Real)

AF Area factor depends on type (Real > 0.0 or blank)

G1,G2,G3,G4 Grid point identification of connected points (Integer > 0 or blank)

Remarks:

1. The heat flux applied to the area is transformed to loads on the points. These points need not correspond to an HBDY element.
2. The flux is applied to each point, i , by the equation
$$P_i = \text{AREA}_i \cdot Q_0,$$
 where Q_0 is positive for heat input, and AREA_i is the portion of the total area associated with point i .
3. In statics, the load is applied with the Case Control request: $L0AD = \text{SID}$. In dynamics, the load is applied by reference on a $TL0ADi$ data card. The load at each point will be multiplied by the function of time $F(t-\tau_i)$ defined on the $TL0ADi$ card. τ_i is the delay factor for each point.
4. The number of connected points for the five types are 1(P0INT), 2(LINE,REV), 3(AREA3), 4(AREA4). Any unused G_i entries must be on the right.
5. The area factor AF is used to determine the effective area for the P0INT and LINE types. It equals the area and the effective width, respectively. It is ignored for the other types, which have their area defined implicitly.
6. The type flag defines a surface in the same manner as the CHBDY data card. For physical descriptions of the geometry involved, see the CHBDY description.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card QVECT

Thermal Vector Flux Load

Description: Defines thermal vector flux from a distant source into HBDY elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QVECT	SID	Q0	E1	E2	E3	EID1	EID2	EID3	abc
QVECT	333	1.-2	-1.0	0.0	0.0	721	722	723	ABC
+bc	EID4	EID5	-etc.-						def
+BC	724								

-etc.-

Field

Contents

SID Load set identification number (Integer > 0)

Q0 Magnitude of thermal flux vector (Real)

E1,E2,E3 Vector components (in basic coordinate system) of the thermal vector flux (Real or Integer > 0). The total flux is given by $Q = Q0\{E1,E2,E3\}$

EID_i Element identification numbers of HBDY elements irradiated by the distant source (Integer > 0)

Remarks:

1. For statics, the load set is selected in the Case Control Deck (LOAD = SID). The total power into an element is given by

$$P_{in} = -\alpha A(\bar{e} \cdot \bar{n}) * Q0,$$

where:

α = absorbtivity
 A = area of HBDY element
 \bar{e} = vector of real numbers E1, E2, E3
 \bar{n} = positive normal vector of element, see CHBDY data card description
 $(\bar{e} \cdot \bar{n})^*$ = 0 if the vector product is positive (i.e., the flux is coming from behind the element)

2. For transient analysis, the load set (SID) is selected by a TLØADi card which defines a load function of time. The total power into the element is given by

$$P_{\rho}(t) = -\alpha A(\bar{e}(t) \cdot \bar{n}) * Q0 F(t-\tau),$$

where:

α, A , and \bar{n} are the same as the statics case
 $\bar{e}(t)$ = vector of three functions of time, which may be given on TABLEDi data cards. If E1, E2, or E3 is an integer, it is the table identification number. If E1, E2, or E3 is a real number, its value is used directly; if Ei is blank, its value is zero.
 $F(t-\tau)$ is a function of time specified or referenced by the parent TLØAD1 or TLØAD2 card. The value τ is calculated for each loaded point.

NASTRAN DATA DECK

QVECT (Cont.)

3. If the referenced HBDY element is of TYPE = ELCYL, the power input is an exact integration over the area exposed to the thermal flux vector.
4. If the referenced HBDY element is of TYPE = REV, the vector should be parallel to the basic z axis.
5. If a sequential list of elements is desired, fields 4, 5, and 6 may specify the first element, the BCD string "THRU", and the last element. No subsequent data is allowed with this option.

BULK DATA DECK

Input Data Card QVØL

Volume Heat Addition

Description: Defines a rate of internal heat generation in an element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QVØL	SID	QV	EID1	EID2	EID3	EID4	EID5	EID6	abc
QVØL	333	1.+2	301	302	303	317	345	416	ABC
+bc	EID7	-etc.-							def
+BC	127								

-etc.-

Field

Contents

SID Load set identification (Integer > 0)

QV Power input per unit volume produced by a heat conduction element (Real)

EIDi A list of heat conduction elements (Integer > 0 or BCD "THRU")

Remarks:

1. In statics, the load is applied with the case control request, LØAD = SID. The equivalent power into each grid point, i, connected to each element, is given by

$$P_i = QV \cdot VØL_i ,$$

where $VØL_i$ is the portion of the volume associated with point i and QV is positive for heat generation.

2. In dynamics, the load is requested by reference on a TLØADi data card. The equivalent power into each grid point i is

$$P_i = QV \cdot VØL_i \cdot F(t - \tau_i) ,$$

where $VØL_i$ is the portion of the volume associated with point i and $F(t - \tau_i)$ is the function of time defined by a TLØADi card. τ_i is the delay for each point i.

3. If a sequential list of elements is desired, fields 4, 5, and 6 may specify the first element identification number, the BCD string "THRU" and the last element identification number. No subsequent data is allowed with this option.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RADLST

List of Radiation Areas

Description: A list of HBDY identification numbers given in the same order as the columns of the RADMTX matrix.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RADLST	EID1	EID2	EID3	EID4	EID5	EID6	EID7	EID8	abc
RADLST	10	20	30	50	31	41	THRU	61	ABC
+bc	EID9	-etc.-							def
+BC	71								

-etc.-

Field

Contents

EIDi The element identification numbers of the HBDY elements, given in the order that they appear in the RADMTX matrix (Integer > 0 or BCD "THRU")

Remarks:

1. This card is required if a RADMTX is defined.
2. Only one RADLST card string is allowed in a data deck.
3. If a group of the elements are sequential, any field except 2 and 9 may contain the BCD word "THRU". Element Id numbers will be generated for every integer between the value of the previous field and the value of the subsequent field. The values must increase, however.
4. Any element may be listed more than once. For instance, if both sides of a panel are radiating, each side may participate in a different part of the view factor matrix.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RADMTX

Radiation Matrix

Description: Matrix of radiation exchange coefficients for nonlinear heat transfer analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RADMTX	INDEX	Fi,i	Fi+1,i	Fi+2,i	Fi+3,i	Fi+4,i	Fi+5,i	Fi+6,i	abc
RADMTX	3	0.	9.3	17.2	16.1	.1	0.	6.2	ABC
+bc	Fi+7,i	-etc.-							def
+BC	6.2								

-etc.-

Field

Contents

INDEX The column number of the matrix (Integer > 0)

Fi+k,i The matrix values (Real), starting on the diagonal, continuing down the column. A group of zero's at the bottom of the column may be omitted. A blank field will end the column, which disallows imbedded blank fields.

Remarks:

1. The INDEX numbers go from 1 thru NA, where NA is the number of radiating areas.
2. The radiation exchange coefficient matrix is symmetric, and only the lower triangle is input. Column 1 is associated with the HBDY element first listed on the RADLST card, Column 2 for the next, etc. Null columns need not be entered.

$$3. P_i = \sum_{j=1}^{NA} F_{ij} q_j$$

P_i = total irradiation into element i

q_j = radiosity (per unit area) at j

F_{ij} = radiation matrix (units of area)

4. A column may only be specified once.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RANDPS

Power Spectral Density Specification

Description: Defines load set power spectral density factors for use in Random Analysis having the frequency dependent form

$$S_{jk}(F) = (X + iY) G(F)$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
RANDPS	SID	J	K	X	Y	TID			
RANDPS	5	3	7	2.0	2.5	4			

Field

Contents

SID	Random analysis set identification number (Integer > 0)
J	Subcase identification number of excited load set (Integer > 0)
K	Subcase identification number of applied load set (Integer \geq 0; K \geq J)
X,Y	Components of complex number (Real)
TID	Identification number of a TABRNDi card which defines G(F) (Integer \geq 0)

Remarks:

1. If J = K, then Y must be 0.0.
2. For TID = 0, G(F) = 1.0.
3. Set identification numbers must be selected in the Case Control Deck (RANDØM=SID) to be used by NASTRAN.
4. Only 20 unique sets may be defined. As many RANDPS cards as desired with the same SID may be input, however.
5. RANDPS can only reference subcases included within a single loop (change in direct matrix input is not allowed).

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RANDT1 Autocorrelation Function Time Lag

Description: Defines time lag constants for use in random analysis autocorrelation function computation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RANDT1	SID	N	T0	TMAX					
RANDT1	5	10	3.2	9.6					

<u>Field</u>	<u>Contents</u>
SID	Random analysis set identification number (Integer > 0)
N	Number of time lag intervals (Integer > 0)
T0	Starting time lag (Real ≥ 0.0)
TMAX	Maximum time lag (Real > T0)

- Remarks:
1. At least one RANDPS card must be present with the same set identification number.
 2. The time lags defined on this card are given by

$$T_i = T_0 + \frac{T_{\max} - T_0}{N} (i - 1), \quad i = 1, N + 1$$

3. Time lag sets must be selected in the Case Control Deck (RANDØM=SID) to be used by NASTRAN.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RELES

Release Substructure Connectivities

Description: Defines sets of component degrees of freedom at substructure grid points which are not to be connected.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RELES	SID	NAME	G1	C1	G2	C2	G3	C3	def
RELES	6	WINGRT	17	456	18	456	21	123	DEF
+ef	G4	C4	etc.		GN	CN			
+EF	25	456							

Field

Contents

SID Set identification number (Integer > 0)
NAME Name of basic substructure (BCD)
Gi Grid or scalar point identification number (Integer > 0)
Ci Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.

- Remarks:
1. The RELES data will override any connections generated automatically from geometry and any connections defined on CØNCT data cards.
 2. The RELES data will not override connections defined on the CØNCT1 data card.
 3. Connectivity sets must be selected in the Substructure Control Deck (CØNNECT=SID) to be used by NASTRAN. Note that 'CØNNECT' is a subcommand of the substructure CØMBINE command.
 4. Connectivities defined during previously executed CØMBINE operations will be retained and may be referenced by the grid point ID and component of any one of the basic substructures associated with that connectivity.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RFØRCE

Rotational Force

Description: Defines a static loading condition due to a centrifugal force field.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RFØRCE	SID	G	CID	A	N1	N2	N3		
RFØRCE	2	5		-6.4	0.0	0.0	1.0		

Field

Contents

SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer ≥ 0)
CID	Coordinate system defining rotation direction (Integer ≥ 0)
A	Scale factor for rotational velocity in revolutions per unit time (Real)
N1 } N2 } N3 }	Rectangular components of rotation direction vector (Real; $N1^2 + N2^2 + N3^2 > 0.0$) The vector defined will act at point G.

- Remarks:
1. G = 0 means the basic coordinate system origin.
 2. CID = 0 means the basic coordinate system.
 3. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
 4. Rotational force sets can be combined with other static loads only by using the LØAD bulk data card.
 5. The load vector generated by this card can be printed with an ØLØAD request in the Case Control Deck.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RINGAX

Axisymmetric Ring

Description: Defines a ring for a model containing CCONEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RINGAX	ID		R	Z			PS		
RINGAX	3		2.0	-10.0			162		

<u>Field</u>	<u>Contents</u>
ID	Ring identification number (Integer > 0)
R	Ring radius (Real > 0.0)
Z	Ring axial location (Real)
PS	Permanent single-point constraints (any unique combination of the digits 1-6)

- Remarks:
1. This card is allowed if and only if an AXIC card is also present.
 2. The number of degrees of freedom defined is $(6-PS) \cdot H$ where H is the harmonic count and PS is the number of digits in field 8. (See AXIC card.)
 3. RINGAX identification numbers must be unique with respect to all other PPOINTAX, RINGAX and SECTAX identification numbers.
 4. The fourth and sixth degrees of freedom must be constrained when transverse shear flexibility is not included for the conical shell.
 5. For a discussion of the conical shell problem see Section 5.9 of the Theoretical Manual.
 6. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RINGFL Axisymmetric Fluid Point

Description: Defines a circle (fluid point) in an axisymmetric fluid model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RINGFL	IDF	X1	X2	X3	IDF	X1	X2	X3	
RINGFL	3	1.0		30.0					

Field

Contents

IDF Unique identification number of the fluid point (Integer, $0 < IDF < 10^5$)
 X1,X2,X3 Coordinates of point in fluid coordinate system defined on AXIF card (Real;
 X1 > 0.0)

- Remarks:
1. This card is allowed only if an AXIF card is also present.
 2. All fluid point identification numbers must be unique with respect to other scalar, structural and fluid points.
 3. X1, X2, X3 are (r, ϕ , z) for a cylindrical coordinate system and (ρ , θ , ϕ) for a spherical coordinate system. θ is in degrees. The value of ϕ must be blank or zero.
 4. One or two fluid points may be defined per card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RLØAD1

Frequency Response Dynamic Load

Description: Defines a frequency dependent dynamic load of the form

$$\{P(f)\} = \{A[C(f) + iD(f)] e^{i\{\theta - 2\pi f\tau\}}\}$$

for use in frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RLØAD1	SID	L	M	N	TC	TD			
RLØAD1	5	3	6	9	1	2			

Field

Contents

SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer ≥ 0)
N	Identification number of DPHASE card set which defines θ (Integer ≥ 0)
TC	Set identification number of TABLEDi card which gives C(f) (Integer ≥ 0 ; TC + TD > 0)
TD	Set identification number of TABLEDi card which gives D(f) (Integer ≥ 0 ; TC + TD > 0)

- Remarks:
1. If any of M, N, TC or TD are blank or zero, the corresponding τ , θ , C(f), or D(f) will be zero.
 2. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
 3. RLØAD1 loads may be combined with RLØAD2 loads only by specification on a DLØAD card. That is, the SID on a RLØAD1 card may not be the same as that on a RLØAD2 card.
 4. SID must be unique for all RLØAD1, RLØAD2, TLØAD1 and TLØAD2 cards.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card RLØAD2

Frequency Response Dynamic Load

Description: Defines a frequency dependent dynamic load of the form

$$\{P(f)\} = \{AB(f)e^{i\{\phi(f) + \theta - 2\pi f\tau\}}\}$$

for use in frequency response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RLØAD2	SID	L	M	N	TB	TP			
RLØAD2	5	3	6	21	7	2			

Field

Contents

SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer ≥ 0)
N	Identification number of DPHASE card set which defines θ in degrees (Integer ≥ 0)
TB	Set identification number of TABLEDi card which gives B(f) (Integer > 0)
TP	Set identification number of TABLEDi card which gives $\phi(f)$ in degrees (Integer ≥ 0)

- Remarks:
1. If any of M, N or TP are zero, the corresponding τ , θ or $\phi(f)$ will be zero.
 2. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
 3. RLØAD2 loads may be combined with RLØAD1 loads only by specification on a DLØAD card. That is, the SID on a RLØAD2 card may not be the same as that on a RLØAD1 card.
 4. SID must be unique for all RLØAD1, RLØAD2, TLØAD1 and TLØAD2 cards.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SECTAX

Axisymmetric Sector

Description: Defines a sector of a model containing CCONEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SECTAX	ID	RID	R	PHI1	PHI2				
SECTAX	1	2	3.0	30.0	40.0				

<u>Field</u>	<u>Contents</u>
ID	Sector identification number (Unique Integer > 0)
RID	Ring identification number (see RINGAX)(Integer > 0)
R	Effective radius (Real)
PHI1 } PHI2 }	Azimuthal limits of sector in degrees (Real)

- Remarks:
1. This card is allowed if and only if an AXIC card is also present.
 2. SECTAX identification numbers must be unique with respect to all other PØINTAX, RINGAX and SECTAX identification numbers.
 3. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
 4. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SEQEP

Extra Point Resequencing

Description: The purpose of this card is to allow the user to reidentify the formation sequence of the extra points of his structural model in such a way as to optimize bandwidth which is essential for efficient solutions by the displacement method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SEQEP	ID	SEQID	ID	SEQID	ID	SEQID	ID	SEQID	
SEQEP	5392	15.6			2	1.9.2.6	3	2	

Field

Contents

ID Extra point identification number (Integer > 0)
 SEQID Sequenced identification number (a special number described below)

- Remarks:
1. ID is any extra point identification number which is to be reidentified for sequencing purposes. The sequence number is a special number which may have any of the following forms where X is a decimal integer digit - XXXX.X.X.X, XXXX.X.X, XXXX.X or XXXX where any of the leading X's may be omitted. This number must contain no imbedded blanks.
 2. If the user wishes to insert an extra point between two already existing grid, scalar and/or extra points, such as 15 and 16, for example, he would define it as, say 5392, and then use this card to insert extra point number 5392 between them by equivalencing it to, say, 15.6. All output referencing this point will refer to 5392.
 3. The SEQID numbers must be unique and may not be the same as a point ID which is not being changed. No extra point ID may be referenced more than once.
 4. No continuation cards (small field or large field) are allowed with either the SEQGP or the SEQEP card.
 5. From one to four extra points may be resequenced on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SEQGP Grid and Scalar Point Resequencing

Description: Used to order the grid points and user-supplied scalar points of the problem. The purpose of this card is to allow the user to reidentify the formation sequence of the grid and scalar points of his structural model in such a way as to optimize bandwidth which is essential for efficient solutions by the displacement method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SEQGP	ID	SEQID	ID	SEQID	ID	SEQID	ID	SEQID	
SEQGP	5392	15.6			2	1.9.2.6	3	2	

Field

Contents

ID Grid or scalar point identification number (Integer > 0)
 SEQID Sequenced identification number (a special number described below)

- Remarks:
1. ID is any grid or scalar point identification number which is to be reidentified for sequencing purposes. The grid point sequence number (SEQID) is a special number which may have any of the following forms where X is a decimal integer digit - XXXX.X.X.X, XXXX.X.X, XXXX.X or XXXX where any of the leading X's may be omitted. This number must contain no imbedded blanks.
 2. If the user wishes to insert a grid point between two already existing grid points, such as 15 and 16, for example, he would define it as, say 5392, and then use this card to insert grid point number 5392 between them by equivalencing it to, say 15.6. All output referencing this point will refer to 5392.
 3. The SEQID numbers must be unique and may not be the same as a point ID which is not being changed. No grid point ID may be referenced more than once.
 4. No continuation cards (small field or large field) are allowed with either the SEQGP or the SEQEP card.
 5. From one to four grid or scalar points may be resequenced on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SET1

Grid Point List

Description: Defines a set of structural grid points by a list.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SET1	SID	G1	G2	G3	G4	G5	G6	G7	ABC
SET1	3	31	62	93	124	16	17	18	ABC
+BC	G8	--etc.--							
+BC	19								

Field

Contents

SID Set of identification numbers (Integer > 0).

G1,G2, etc. List of structural grid points (Integer > 0 or "THRU").

Remarks:

1. These cards are referenced by the SPLINE data cards.
2. When using the "THRU" option, all intermediate grid points must exist. The word "THRU" may not appear in field 3 or 9 (2 or 9 for continuation cards).

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SET2

Grid Point List

Description: Defines a set of structural grid points in terms of aerodynamic macro elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SET2	SID	MACRØ	SP1	SP2	CH1	CH2	ZMAX	ZMIN	
SET2	3	111	.0	.75	0.	.667	1.0	-3.51	

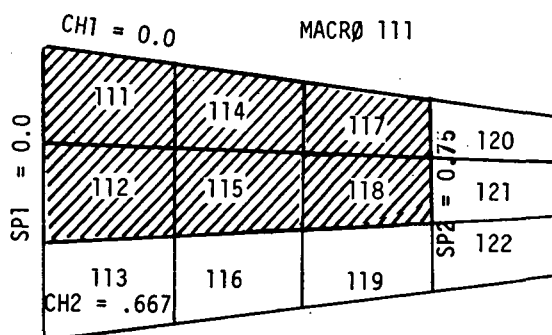
Field

Contents

SID	Set identification number (Integer > 0).
MACRØ	Element identification number of an aero macro element (Integer > 0).
SP1,SP2	Lower and higher span division points defining prism containing set (Real).
CH1,CH2	Lower and higher chord division points defining prism containing set (Real).
ZMAX,ZMIN	Top and bottom (using right-hand rule with the order the corners as listed on a CAERØ card) of the prism containing set (Real). Usually $ZMAX \geq 0$, $ZMIN \leq 0$.

Remarks:

1. These cards are referenced by the SPLINEi data cards.
2. Every grid point, within the defined prism and within the height range, will be in the set.
For example,



The shaded area in the figure defines the cross-section of the prism for the sample data given above. Points exactly on the boundary may be missed, hence, to get the area of the macro element, use $SP1 = -.01$, $SP2 = 1.01$, etc.

3. A zero value for ZMAX or ZMIN implies infinity is to be used.
4. To find the (internal) grid ID's found, use DIAG 18.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SLBDY Slot Boundary List

Description: Defines a list of slot points which lie on an interface between an axisymmetric fluid and a set of evenly spaced radial slots.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SLBDY	RHØ	M	ID1	ID2	ID3	ID4	ID5	ID6	abc
SLBDY	0.002	6	16	17	18	25	20	21	+BDY
+bc	ID7	-etc.-							+def
+BDY	22								

- etc. -

<u>Field</u>	<u>Contents</u>
RHØ	Density of fluid at boundary (Real > 0.0, or blank)
M	Number of slots (Integer ≥ 0, or blank)
IDj	Identification numbers of GRIDS slot points at boundary with axisymmetric fluid cavity, j = 1,2,...,J (Integer > 0)

- Remarks:
1. This card is allowed only if an AXSLØT card is also present.
 2. If RHØ or M is "blank" the default value on the AXSLØT card is used. The effective value must not be zero for RHØ. If the effective value of M is zero, no matrices at the boundary will be generated.
 3. The order of the list of points determines the topology of the boundary. The points are listed sequentially as one travels along the boundary in either direction. At least two points must be defined.
 4. More than one logical boundary card may be used.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SLØAD Static Scalar Load

Description: Used to apply static loads to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SLØAD	SID	S	F	S	F	S	F		
SLØAD	16	2	5.9	17	-6.3	14	-2.93		

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scalar point identification number (Integer > 0)
F	Load value (Real)

- Remarks:
1. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
 2. Up to three scalar loads may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SPC Single-Point Constraint

Description : Defines sets of single-point constraints and enforced displacements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPC	SID	G	C	D	G	C	D		
SPC	2	32	436	-2.6	5		+2.9		

<u>Field</u>	<u>Contents</u>
SID	Identification number of single-point constraint set (Integer > 0)
G	Grid or scalar point identification number (Integer > 0)
C	Component number ($6 \geq \text{Integer} \geq 0$; up to six unique such digits may be placed in the field with no imbedded blanks)
D	Value of enforced displacement for all coordinates designated by G and C (Real)

- Remarks:
1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation (MPC card), nor may it be referenced on a SPC1, OMIT, OMIT1 or SUPORT card. D must be 0.0 for dynamics problems.
 2. Single-point forces of constraint are recovered during stress data recovery.
 3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
 4. From one to twelve single-point constraints may be defined on a single card.
 5. SPC degrees of freedom may be redundantly specified as permanent constraints on the GRID card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SPC1

Single-Point Constraint

Description: Defines sets of single-point constraints.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPC1	SID	C	G1	G2	G3	G4	G5	G6	abc
SPC1	3	2	1	3	10	9	6	5	ABC
+bc	G7	G8	G9	-etc.-					
+BC	2	8							

Alternate Form

SPC1	SID	C	GID1	"THRU"	GID2				
SPC1	313	12456	6	THRU	32				

Field

Contents

- SID Identification number of single-point constraint set (Integer > 0)
- C Component number (Any unique combination of the digits 1-6 (with no imbedded blanks) when point identification numbers are grid points; must be null if point identification numbers are scalar points)
- Gi, GIDi Grid or scalar point identification numbers (Integer > 0)

- Remarks:
1. Note that enforced displacements are not available via this card. As many continuation cards as desired may appear when "THRU" is not used.
 2. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPC, OMIT, OMIT1, SUPORT card.
 3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
 4. SPC degrees of freedom may be redundantly specified as permanent constraints on the GRID card.
 5. All grid points referenced by GID1 thru GID2 must exist.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SPCADD Single-Point Constraint

Description: Defines a single-point constraint set as a union of single-point constraint sets defined via SPC or SPC1 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCADD	SID	S1	S2	S3	S4	S5	S6	S7	abc
SPCADD	101	3	2	9	1				
+bc	S8	S9	-etc.-						

-etc.-

Field

Contents

SID Identification number for new single-point constraint set (Integer > 0)

Si Identification numbers of single-point constraint sets defined via SPC or SPC1 cards (Integer > 0; SID ≠ Si)

- Remarks:
1. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
 2. No Si may be the identification number of a single-point constraint set defined by another SPCADD card.
 3. The Si values must be unique.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SPCAX Axisymmetric Single-Point Constraint

Description: Defines sets of single-point constraints for a model containing CCONEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCAX	SID	RID	HID	C	V				
SPCAX	2	3	4	13	6.0				

<u>Field</u>	<u>Contents</u>
SID	Identification number of single-point constraint set (Integer > 0)
RID	Ring identification number (see RINGAX) (Integer ≥ 0)
HID	Harmonic identification number (Integer ≥ 0)
C	Component identification number (any unique combination of the digits 1-6)
V	Enforced displacement value (Real)

- Remarks:
1. This card is allowed if and only if an AXIC card is also present.
 2. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
 3. Coordinates appearing on SPCAX cards may not appear on MPCAX, SUPAX or OMITAX cards.
 4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
 5. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

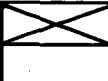
BULK DATA DECK

Input Data Card SPCD

Enforced Displacement Value

Description: Defines an enforced displacement value for static analysis, which is requested as a LØAD.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCD	SID	G	C	D	G	C	D		
SPCD	100	32	436	-2.6	5		+2.9		

Field

Contents

SID	Identification number of a static load set (Integer > 0)
G	Grid or scalar point identification number (Integer > 0)
C	Component number ($6 \geq \text{Integer} \geq 0$; up to six unique such digits may be placed in the field with no imbedded blanks.)
D	Value of enforced displacement for all coordinates designated by G and C (Real)

- Remarks:
1. A coordinate referenced on this card must be referenced by a selected SPC or SPC1 data card.
 2. Values of D will override the values specified on an SPC bulk data card, if the LØAD set is requested.
 3. The bulk data LØAD combination card will not request an SPCD.
 4. At least one bulk data LØAD card (FØRCE, SLØAD, etc.) is required in the LØAD set selected in case control.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SPCS

Substructure Single Point Constraints

Description: Defines a set of single point constraints on a specified basic substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCS	SID	NAME	G1	C1	G2	C2	G3	C3	abc
SPCS	61	MIDWG	9	45	18	124	36	456	ABC
+bc	G4	C4	G5	C5	G6	C6	G7	C7	def
+BC	88	136	etc.						

Field

Contents

SID Set identification number (Integer > 0)

NAME Basic substructure name (BCD)

Gi Grid or scalar point identification number in substructure (Integer > 0)

Ci Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.

- Remarks:
1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPCS1, SPCSD, SPC, SPC1, OMIT, OMIT1 or SUPORT card.
 2. Single-point forces of constraint are recovered during stress data recovery.
 3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
 4. A single G, C pair may not specify all component degrees of freedom for a connected grid point where only some of the degrees of freedom of the grid point have been connected or when some have been disconnected via the RELES card. The degrees of freedom which were connected and those that were not connected must be referenced separately.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SPCS1 Substructure Single Point Constraints

Description: Defines a set of single point constraints on a specified basic substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCS1	SID	NAME	C	G1	G2	G3	G4	G5	abc
SPCS1	15	FUSELAGE	1236	1101	1102	1105	THRU	1110	ABC
+bc	G6	G7	G8	G9	G10	G11	G12	G13	def
+BC	1121	1130	THRU	1140	1143	1150	etc.		

<u>Field</u>	<u>Contents</u>
SID	Set identification number (Integer > 0)
NAME	Basic substructure name (BCD)
C	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points
Gi	Grid or scalar point identification numbers (Integer > 0)

- Remarks:
1. THRU may appear in fields 6, 7, or 8 of the first card and anywhere in fields 3 - 8 on a continuation card.
 2. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPCS, SPCSD, SPC, SPC1, ØMIT, ØMIT1, or SUPØRT card.
 3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
 4. All grid points referenced by Gi through Gj must exist.
 5. A single G, C pair may not specify all component degrees of freedom for a connected grid point where only some of the degrees of freedom of the grid point have been connected or when some have been disconnected via the RELES card. The degrees of freedom which were connected and those that were not connected must be referenced separately.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SPCSD

Substructure Single Point Constraints

Description: Defines a set of single point constraints and enforced displacements for a given substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCSD	SID	NAME	G1	C1	D1	G2	C2	D2	
SPCSD	27	LWINGRT	965	3	3.6				

Field

Contents

SID	Set identification number (Integer > 0)
NAME	Basic substructure name (BCD)
Gi	Grid or scalar point identification number (Integer > 0)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.
Di	Value of enforced displacement for all coordinates designated by Gi and Ci (Real)

Remarks

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPCS, SPCS1, SPC, SPC1, OMIT, OMIT1, or SUPORT card. The Di values are ignored in dynamics problems.
2. Single-point forces of constraint are recovered during stress data recovery.
3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
4. From one to twelve single-point constraints may be defined on a single card.
5. A single G, C pair may not specify all component degrees of freedom for a connected grid point where only some of the degrees of freedom of the grid point have been connected or when some have been disconnected via the RELES card. The degrees of freedom which were connected and those that were not connected must be referenced separately.

NASTRAN DATA DECK

BULK DATA DECK

Surface Spline

Description: Defines a surface spline for interpolating out-of-plane motion for aeroelastic problems.

Format and Example:

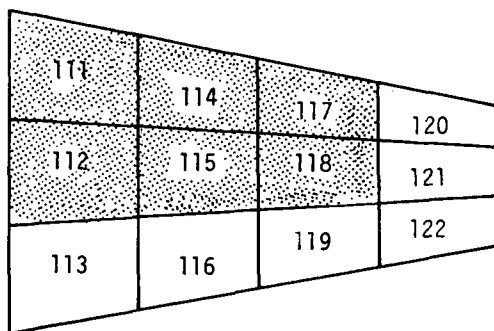
1	2	3	4	5	6	7	8	9	10
SPLINE1	EID	CAERO	BØX1	BØX2	SETG	DZ			
SPLINE1	3	111	111	118	14				

Contents

EID	Element identification number (unique Integer > 0).
CAERO	Aero element ID which defines plane of spline (Integer > 0).
B0X1,B0X2	First and last box whose motions are interpolated using this spline (Integer > 0).
SETG	Refers to a SETi card which lists the structural grid points to which the spline is attached (Integer > 0).
DZ	Linear attachment flexibility (Real ≥ 0).

Remarks :

1. The interpolated points (k-set) will be defined by aero-cells. The sketch shows the cells for which u_k is interpolated if $B0X1 = 111$ and $B0X2 = 118$.



2. The attachment flexibility (units of area) is used for smoothing the interpolation. If $DZ = 0$, the spline will pass thru all deflected grid points. If $DZ \gg (\text{area of spline})$, a least squares plane fit will occur. Intermediate values will provide smoothing.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SPLINE2

Linear Spline

Description: Defines a beam spline for interpolating out-of-plane motion for aeroelastic problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPLINE2	EID	CAERØ	BØX1	BØX2	SETG	DZ	DTØR	CID	ABC
SPLINE2	5	8	12	24	60		1.0	3	
+BC	DTHX	DTHY							
	-1.								

Field

Contents

EID	Element identification number (unique Integer > 0).
CAERØ	Aero element which defines plane of spline (Integer > 0).
BØX1,BØX2	First and last box whose motions are interpolated using this spline (Integer > 0).
SETG	Refers to a SETi card which lists the structural "g"-set to which the spline is attached (Integer > 0).
DZ	Linear attachment flexibility (Real > 0).
DTØR	Torsional flexibility (EI/GJ) (Real > 0).
CID	Rectangular coordinate system which defines y-axis of spline (Integer ≥ 0).
DTHX,DTHY	Torsional attachment flexibility (Real).

Remarks:

1. The interpolated points (k-set) will be defined by aero cells.
2. The y-axis of the spline is the projection of the y-axis of the coordinate system CID, projected onto the plane of the spline.
3. The flexibilities are used for smoothing. Zero attachment flexibility values will imply rigid attachment, i.e., no smoothing. (Negative values in fields 12 and 13 will imply infinity, hence no attachment. Do not use negative value for DTHY if grid points are on a straight line.)
4. A continuation card is required.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SPØINT

Scalar Point

Description: Defines scalar points of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPØINT	ID	ID	ID	ID	ID	ID	ID	ID	
SPØINT	3	18	1	4	16	2			

Alternate Form

SPØINT	ID1	"THRU"	ID2						
SPØINT	5	THRU	649						

Field

Contents

ID, ID1, ID2 Scalar point identification number (Integer > 0; ID1 < ID2)

- Remarks:
1. Scalar point defined by their appearance on a scalar connection card need not appear on a SPØINT card.
 2. All scalar point identification numbers must be unique with respect to all other structural, scalar, and fluid points.
 3. This card is used primarily to define scalar points appearing in single or multipoint constraint equations but to which no scalar elements are connected.
 4. If the alternate form is used, scalar points ID1 thru ID2 are defined.
 5. For a discussion of scalar points, see Section 5.6 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SUPAX

Axisymmetric Fictitious Support

Description: Defines coordinates at which the user desires determinate reactions to be applied during the analysis of a free body modeled with CCONEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SUPAX	RID	HID	C	RID	HID	C			
SUPAX				4	3	2			

Field

Contents

RID Ring identification number (Integer > 0)
HID Harmonic identification number (Integer ≥ 0)
C Component number (any unique combination of the digits 1-6)

- Remarks:
1. This card is allowed if and only if an AXIC card is also present.
 2. Up to 12 coordinates may appear on a single card.
 3. Coordinates appearing on SUPAX cards may not appear on MPCAX, SPCAX or OMITAX cards.
 4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
 5. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card SUPØRT

Fictitious Support

Description: Defines coordinates at which the user desires determinate reactions to be applied to a free body during analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SUPØRT	ID	C	ID	C	ID	C	ID	C	
SUPØRT	16	215							

Field

Contents

ID Grid or scalar point identification number (Integer > 0)

C Component number (Zero or blank for scalar points; any unique combination of the digits 1-6 for grid points)

Remarks: 1. Coordinates defined on this card may not appear on single-point constraint cards (SPC, SPC1), on omit cards (ØMIT, ØMIT1) or in multipoint constraint equations as dependent coordinates (MPC).

2. From one to twenty-four support coordinates may be defined on a single card.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABDMP1

Structural Damping Table

Description: Defines structural damping as a tabular function of frequency.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABDMP1	ID								abc
TABDMP1	3								ABC
+bc	f ₁	g ₁	f ₂	g ₂	f ₃	g ₃	f ₄	g ₄	
+BC	2.5	.01057	2.6	.01362	ENDT				

(etc.)

Field

Contents

ID Table identification number (Integer > 0)
f_i Frequency value in cycles per unit time (Real ≥ 0.0)
g_i Damping value (Real)

- Remarks:
1. The f_i must be in either ascending or descending order but not both.
 2. Jumps (f_i = f_{i+1}) are allowed, but not at the end points.
 3. At least two entries must be present.
 4. Any f_i, g_i entry may be ignored by placing the BCD string "SKIP" in either of two fields used for that entry.
 5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 6. The TABDMP1 mnemonic infers the use of the algorithm

$$G = g_T(F)$$

where F is input to the table and G is returned. The table look-up g_T(F) is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average g_T(F) is used. There are no error returns from this table look-up procedure.

7. Structural damping tables must be selected in the Case Control Deck (SDAMP=ID) to be used by NASTRAN.
8. Structural damping is used only in modal formulations of complex eigenvalue analysis, frequency response analysis, or transient response analysis.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABLED1

Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED1	ID								+abc
TABLED1	32								ABC
+abc	x ₁	y ₁	x ₂	y ₂	x ₃	y ₃	x ₄	y ₄	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

-etc.-

Field

Contents

ID Table identification number (Integer > 0)

x_i, y_i Tabular entries (Real)

- Remarks:
1. The x_i must be in either ascending or descending order but not both.
 2. Jumps between two points (x_i = x_{i+1}) are allowed, but not at the end points.
 3. At least two entries must be present.
 4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
 5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED1 type tables, this algorithm is

$$Y = y_T(X)$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABLED2

Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED2	ID	X1							+abc
TABLED2	15	-10.5							ABC
+abc	x ₁	y ₁	x ₂	y ₂	x ₃	y ₃	x ₄	y ₄	+def
+BC	1.0	-4.5	2.0	-4.2	2.0	2.8	7.0	6.5	DEF
+def	x ₅	y ₅	x ₆	y ₆	x ₇	y ₇	x ₈	y ₈	+ghi
+EF	SKIP	SKIP	9.0	6.5	ENDT				

(etc.)

Field

Contents

ID Table identification number (Integer > 0)
X1 Table parameter (Real)
x_i, y_i Tabular entries (Real)

- Remarks:
1. The x_i must be in either ascending or descending order but not both.
 2. Jumps between two points (x_i = x_{i+1}) are allowed, but not at the end points.
 3. At least two entries must be present.
 4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
 5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED2 type tables, this algorithm is

$$Y = y_T(X - X1)$$

where X is input to the table and Y is returned. The table look-up y_T(x), x = X-X1, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average y_T(x) is used. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABLED3

Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED3	ID	X1	X2						+abc
TABLED3	62	126.9	30.0						ABC
+abc	x ₁	y ₁	x ₂	y ₂	x ₃	y ₃	x ₄	y ₄	+def
+BC	2.9	2.9	3.6	4.7	5.2	5.7	ENDT		

-etc.-

<u>Field</u>	<u>Contents</u>
ID	Table identification number (Integer > 0)
X1, X2	Table parameters (Real; X2 ≠ 0.0)
x _i , y _i	Tabular entries (Real)

- Remarks:
1. The x_i must be in either ascending or descending order but not both.
 2. Jumps between two points (x_i = x_{i+1}) are allowed, but not at the end points.
 3. At least two entries must be present.
 4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
 5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED3 type tables, this algorithm is

$$Y = y_T \left(\frac{X - X1}{X2} \right)$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = \frac{X - X1}{X2}$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABLED4

Dynamic Load Tabular Function

Description: Defines coefficients of a power series for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED4	ID	X1	X2	X3	X4				+abc
TABLED4	28	0.0	1.0	0.0	100.				ABC
+abc	A ₀	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	+def
+BC	2.91	-0.0329	6.51-5	0.0	-3.4-7	ENDT			

etc.

Field

Contents

ID Table identification number (Integer > 0)
X1,X2,X3,X4 Table parameters (Real; X2 ≠ 0.0; X3 < X4)
A_i Coefficient entries (Real)

- Remarks:
1. At least one entry must be present.
 2. The end of the table is indicated by the existence of the BCD string "ENDT" in the field following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 3. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED4 type tables, this algorithm is

$$Y = \sum_{i=0}^N A_i \left(\frac{X - X1}{X2} \right)^i$$

where X is input to the table and Y is returned. Whenever X < X3, use X3 for X; whenever X > X4, use X4 for X. There are N + 1 entries in the table. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABLEM1

Material Property Table

Description: Defines a tabular function for use in generating temperature dependent material properties.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM1	ID								+abc
TABLEM1	32								ABC
+abc	x_1	y_1	x_2	y_2	x_3	y_3	x_4	y_4	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

(etc.)

Field

Contents

ID Table identification number (Integer > 0)

x_i, y_i Tabular entries (Real)

- Remarks:
1. The x_i must be in either ascending or descending order but not both.
 2. Jumps between two points ($x_i = x_{i+1}$) are allowed, but not at the end points.
 3. At least two entries must be present.
 4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
 5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 6. Each TABLEMi mnemonic infers the use of a specific algorithm. For TABLEM1 type tables, this algorithm is

$$Y = y_T(X)$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABLEM2

Material Property Table

Description: Defines a tabular function for use in generating temperature dependent material properties. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM2	ID	X1							+abc
TABLEM2	15	-10.5							ABC
+abc	x ₁	y ₁	x ₂	y ₂	x ₃	y ₃	x ₄	y ₄	+def
+BC	1.0	-4.5	2.0	-4.5	2.0	2.8	7.0	6.5	DEF
+def	x ₅	y ₅	x ₆	y ₆	x ₇	y ₇	x ₈	y ₈	+ghi
+EF	SKIP	SKIP	9.0	6.5	ENDT				

(etc.)

Field

Contents

ID Table identification number (Integer > 0)
X1 Table parameter (Real)
x_i, y_i Tabular entries (Real)

- Remarks:
1. The x_i must be in either ascending or descending order but not both.
 2. Jumps between two points (x_i = x_{i+1}) are allowed, but not at the end points.
 3. At least two entries must be present.
 4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
 5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 6. Each TABLEM_i mnemonic infers the use of a specific algorithm. For TABLEM2 type tables, this algorithm is

$$Y = Z y_T(X - X1)$$

where X is input to the table, Y is returned and Z is supplied from the basic MAT_i card. The table look-up y_T(x), x = X - X1, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average y_T(x) is used. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABLEM3

Material Property Table

Description: Defines a tabular function for use in generating temperature dependent material properties. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM3	ID	X1	X2						+abc
TABLEM3	62	126.9	30.0						ABC
+abc	x ₁	y ₁	x ₂	y ₂	x ₃	y ₃	x ₄	y ₄	+def
+BC	2.9	2.9	3.6	4.7	5.2	5.7	ENDT		

(etc.)

Field

Contents

ID Table identification number (Integer > 0)
X1, X2 Table parameters (Real; X2 ≠ 0.0)
x_i, y_i Tabular entries (Real)

- Remarks:
1. The x_i must be in either ascending or descending order but not both.
 2. Jumps between two points (x_i = x_{i+1}) are allowed, but not at the end points.
 3. At least two entries must be present.
 4. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
 5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 6. Each TABLEM_i mnemonic infers the use of a specific algorithm. For TABLEM3 type tables, this algorithm is

$$Y = Z y_T \left(\frac{X - X_1}{X_2} \right)$$

where X is input to the table, Y is returned and Z is supplied from basic MAT_i card. The table look-up $y_T(x)$, $x = \frac{X - X_1}{X_2}$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABLEM4

Material Property Table

Description: Defines coefficients of a power series for use in generating temperature dependent material properties. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLEM4	ID	X1	X2	X3	X4				+abc
TABLEM4	28	0.0	1.0	0.0	100.				ABC
+abc	A ₀	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆	A ₇	+def
+BC	2.91	-0.0329	6.51-5	0.0	-3.4-7	ENDT			

etc.

Field

Contents

ID Table identification number (Integer > 0)
 X1,X2,X3,X4 Table parameters (Real; X2 ≠ 0.0; X3 < X4)
 A_i Coefficient entries (Real)

Remarks: 1. At least one entry must be present.

- The end of the table is indicated by the existence of the BCD string "ENDT" in the field following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
- Each TABLEM_i mnemonic infers the use of a specific algorithm. For TABLEM4 type tables, this algorithm is

$$Y = Z \sum_{i=0}^N A_i \left(\frac{X - X1}{X2} \right)^i$$

where X is input to the table, Y is returned and Z is supplied from the basic MAT_i card. Whenever X < X3, use X3 for X; whenever X > X4, use X4 for X. There are N+1 entries in the table. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABLES1

Tabular Stress-Strain Function

Description: Defines a tabular stress-strain function for use in Piecewise Linear Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLES1	ID								+abc
TABLES1	32								ABC
+abc	x ₁	y ₁	x ₂	y ₂	x ₃	y ₃	x ₄	y ₄	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

-etc.-

Field

Contents

ID Table identification number (Integer > 0)

x_i, y_i Tabular entries (Real)

- Remarks:
1. The x_i must be in either ascending or descending order but not both.
 2. For Piecewise Linear Analysis, the y_i numbers must form a nondecreasing sequence for an ascending x_i sequence and vice versa.
 3. Jumps between two points (x_i = x_{i+1}) are allowed, but not at the end points.
 4. At least two entries must be present.
 5. Any x-y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
 6. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 7. Each TABLESi mnemonic infers the use of a specific algorithm. For TABLES1 type tables, this algorithm is

$$Y = y_T(X)$$

where X is input to the table and Y is returned. The table look-up y_T(x), x = X, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average y_T(x) is used. There are no error returns from this table look-up procedure.

8. The table may have a zero slope only at its end.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TABRND1

Power Spectral Density Table

Description: Defines Power Spectral density as a tabular function of frequency for use in Random Analysis. Referenced on the RANDPS card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABRND1	ID								abc
TABRND1	3								ABC
+bc	f ₁	g ₁	f ₂	g ₂	f ₃	g ₃	f ₄	g ₄	def
+BC	2.5	.01057	2.6	.01362	ENDT				

-etc.-

Field

Contents

ID Table identification number (Integer > 0)
f_i Frequency value in cycles per unit time (Real ≥ 0.0)
g_i Power Spectral Density (Real)

- Remarks:
1. The f_i must be in either ascending or descending order but not both.
 2. Jumps between two points (f_i = f_{i+1}) are allowed, but not at the end points.
 3. At least two entries must be present.
 4. Any f-g entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
 5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
 6. The TABRND1 mnemonic infers the use of the algorithm

$$G = g_T(F)$$

where F is input to the table and G is returned. The table look-up g_T(F) is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average g_T(F) is used. There are no error returns from this table look-up procedure.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TEMP Grid Point Temperature Field

Description: Defines temperature at grid points for determination of:

- 1) Thermal loading
- 2) Temperature-dependent material properties
- 3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMP	SID	G	T	G	T	G	T		
TEMP	3	94	316.2	49	219.8				

Field

Contents

SID Temperature set identification number (Integer > 0)

G Grid point identification number (Integer > 0)

T Temperature (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.
2. From one to three grid point temperatures may be defined on a single card.
3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.
4. If the element material is temperature dependent, its properties are evaluated at the average temperature. In the case of isoparametric hexahedron elements, their properties are evaluated at the temperature computed by interpolating the grid point temperatures.
5. Average element temperatures are obtained as a simple average of the connecting grid point temperatures when no element temperature data are defined.
6. Set ID must be unique with respect to all other LOAD type cards if TEMP(LOAD) is specified in Case Control Deck.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TEMPAX

Axisymmetric Temperature

Description: Defines temperature sets for a model containing CCONEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPAX	SID	RID	PHI	TEMP	SID	RID	PHI	TEMP	
TEMPAX	4	7	30.0	105.3					

Field

Contents

SID Temperature set identification number (Integer > 0)

RID Ring identification number (see RINGAX card) (Integer > 0)

PHI Azimuthal angle in degrees (Real)

TEMP Temperature (Real)

Remarks:

1. This card is allowed if and only if an AXIC card is also present.
2. One or two temperatures may be defined on each card.
3. Temperature sets must be selected in the case Control Deck (TEMP=SID) to be used by NASTRAN.
4. Set ID must be unique with respect to all other LOAD type cards if TEMP(LOAD) is specified in Case Control Deck.
5. At least two different angles are required for each RID and temperature set to specify the subtended angle $[\phi_b - \phi_a]$ over which the temperature applies.
6. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
7. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TEMPD

Grid Point Temperature Field Default

Description: Defines a temperature default for all grid points of the structural model which have not been given a temperature on a TEMP card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPD	SID	T	SID	T	SID	T	SID	T	
TEMPD	1	216.3							

Field

Contents

SID Temperature set identification number (Integer > 0)

T Default temperature (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.
2. From one to four default temperatures may be defined on a single card.
3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.
4. If the element material is temperature dependent its properties are evaluated at the average temperature. In the case of isoparametric hexahedron elements, their properties are evaluated at the temperature computed by interpolating the grid point temperatures.
5. Average element temperatures are obtained as a simple average of the connecting grid point temperatures when no element temperature data are defined.
6. Set ID must be unique with respect to all other LOAD type cards if TEMP(LOAD) is specified in Case Control Deck.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TEMPP1

Plate Element Temperature Field

Description: Defines a temperature field for plate, membrane and combination elements (by an average temperature and a thermal gradient over the cross-section) for determination of:

- 1) Thermal loading
- 2) Temperature-dependent material properties
- 3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPP1	SID	EID1	\bar{T}	T'	T1	T2			+abc
TEMPP1	2	24	62.0	10.0	57.0	67.0			A1A
+abc	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+def
+1A	26	21	19	30					

-etc.-

Alternate Form of Continuation Card

+abc	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+def
+1A	1	THRU	10	30	THRU	61			

-etc.-

Field

Contents

SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: the continuation card may have THRU in fields 3 and/or 6, in which case EID2 < EIDi, EIDj < EIDk)
\bar{T}	Average temperature over the cross-section. Assumed constant over area (Real)
T'	Effective linear thermal gradient. Not used for membranes (Real)
T1, T2	Temperatures for stress calculation at points defined on the element property card. (Z1 and Z2 are given on PTRBSC, PQDPLT, PTRPLT, PTRIAL, and PQUAD1 cards. T1 may be specified on the lower surface and T2 on the upper surface for the QUAD2 and TRIA2 elements. These data are not used for membrane elements (Real)

- Remarks:
1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.
 2. If continuation cards are present, EID1 and elements specified on the continuation card(s) are used. Elements must not be specified more than once.
 3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.
 4. For a temperature field other than a constant gradient the "effective gradient" for a homogeneous plate is:

$$T' = \frac{1}{I} \int_z T(z) z \, dz$$

where I is the bending inertia, and z is the distance from the neutral surface in the positive normal direction.

(Continued)

NASTRAN DATA DECK

TEMPP1 (Cont.)

5. The "average" temperature for a homogeneous plate is

$$\bar{T} = \frac{1}{\text{Volume}} \int_{\text{Volume}} T \, d\text{Volume}$$

6. If the element material is temperature dependent, its properties are evaluated at the average temperature \bar{T} .
7. Set ID must be unique with respect to all other LOAD type cards if TEMP(LOAD) is specified in Case Control Deck.

BULK DATA DECK

Input Data Card TEMPP2

Plate Element Temperature Field

Description: Defines a temperature field for plate, membrane, and combination elements by an average temperature and thermal moments for determination of:

- 1) Thermal loading
- 2) Temperature-dependent material properties
- 3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPP2	SID	EID1	\bar{T}	MX	MY	MX _Y	T1	T2	+abc
TEMPP2	2	36	68.8						XYZ
+abc	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+def
+YZ	400	1	2	5					

-etc.-

Alternate Form of Continuation Card

+abc	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+def
+YZ	37	THRU	312	315	THRU	320			

-etc.-

Field

Contents

SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: a continuation card may have THRU in field 3 and/or 6 in which case EID2 < EIDi, EIDj < EIDk)
\bar{T}	Average temperature over cross-section. Assumed constant over area (Real)
MX, MY, MX _Y	Resultant thermal moments per unit width in element coordinate system. Not used for membrane elements (Real)
T1, T2	Temperature for stress calculation at points defined on the element property card. (Z1 and Z2 are given on PTRBSC, PQDPLT, PTRPLT, PTRIA1, and PQUA01 cards. T1 may be specified on the lower surface and T2 on the upper surface for the QUAD2 and TRIA2 elements. These data are not used for membrane elements (Real)

- Remarks:
1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.
 2. If continuation cards are present, EID1 and elements specified on the continuation card(s) are used. Elements must not be specified more than once.
 3. If thermal effects are requested all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

(Continued)

NASTRAN DATA DECK

TEMPP2 (Cont.)

- The thermal moments in the element coordinate system may be calculated from the formula:

$$\begin{Bmatrix} M_x \\ M_y \\ M_{xy} \end{Bmatrix} = - \int [G_e] \{\alpha_e\} T(z) z \, dz$$

where the integration is performed over the bending material properties in the element coordinate system.

$[G_e]$ - 3x3 elastic coefficient matrix

$\{\alpha_e\}$ - 3x1 material thermal expansion coefficients

$T(z)$ - temperature at z

z - distance from the neutral surface in the element coordinate system.

- The temperature dependent material properties are evaluated at the average temperature T . If a property varies with depth, an effective value must be used which satisfies the desired elastic and stress relationships. The temperatures at the fibre distances may be changed to compensate for local differences in α_e and produce correct stresses.
- Set ID must be unique with respect to all other LOAD type cards if TEMP(LOAD) is specified in Case Control Deck.

BULK DATA DECK

Input Data Card TEMPP3

Plate Element Temperature Field

Description: Defines a temperature field for homogeneous plate, membrane and combination elements (by a tabular description of the thermal field over the cross-section) for determination of:

- 1) Thermal loading
- 2) Temperature-dependent material properties
- 3) Stress recovery.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPP3	SID	EID1	Z0	T0	Z1	T1	Z2	T2	+abc
TEMPP3	17	39	0.0	32.9	2.0	43.4	2.5	45.0	XY1
+abc	Z3	T3	Z4	T4	Z5	T5	Z6	T6	+def
+Y1	3.0	60.0	4.0	90.0					XY2
+def	Z7	T7	Z8	T8	Z9	T9	Z10	T10	+ghi
+Y2									XY3
+ghi	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+jkl
+Y3	1	2	3	4	5	6	8	10	

-etc.-

Alternate Form of Continuation Card Number 3

+ghi	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+jkl
+Y3				1	THRU	10			

-etc.-

Field

Contents

SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: the continuation card may have THRU in fields 3 and/or 6 in which case EID2 < EIDi, EIDj < EIDk)
Z0	Position of the bottom surface with respect to an arbitrary reference plane (Real)
Zi	Positions on cross-section from bottom to top of cross-section relative to the arbitrary reference plane. There must be an increasing sequence with the last nonzero value corresponding to the top surface (Real)
T0	Temperature at the bottom surface (Real)
Zi	Temperature at position Zi (Real)

Remarks: 1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. If the third (and succeeding) continuation card is present, EID1 and elements specified on the third (and succeeding) continuation cards are used. Elements must not be specified more than once.

3. The first and second continuation card must be present if a list of elements is to be used.

(Continued)

NASTRAN DATA DECK

TEMPP3 (Cont.)

4. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.
5. If the element material is temperature dependent, its properties are evaluated at the average temperature over the depth which is calculated by the program using a linear distribution between points.
6. For stress recovery, the temperatures at the extreme points z_0 and z_N are assigned to the bottom surface and the top surface of the elements specified on either PTRIA2 or QUAD2 data card.
7. The data is limited to a maximum of eleven points on the temperature-depth profile.
8. Set ID must be unique with respect to all other LOAD type cards if TEMP(LOAD) is specified in Case Control Deck.

BULK DATA DECK

Input Data Card TEMPRB

One-Dimensional Element Temperature Field

Description: Defines a temperature field for the BAR, RØD, TUBE, and CØNRØD elements for determination of:

- 1) Thermal loading
- 2) Temperature-dependent material properties
- 3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPRB	SID	EID1	$\bar{T}A$	$\bar{T}B$	T'1a	T'1b	T'2a	T'2b	+abc
TEMPRB	200	1	68.0	23.0	0.0	28.0		2.5	AXY10
+abc	TCa	TDa	TEa	TFa	TCb	TDb	TEb	TFb	+def
+XY10	68.0	91.0	45.0		48.0	80.0	20.0		AXY20
+def	EID2	EID3	EID4	EID5	EID6	EID7	EID8	EID9	+ghi
+XY20	9	10							

-etc.-

Alternate Form for Continuation Card Number 2

+def	EID2	"THRU"	EIDi	EIDj	"THRU"	EIDk			+ghi
+XY20	2	THRU	4	10	THRU	14			

-etc.-

Field

Contents

SID	Temperature set identification number (Integer > 0)
EIDn	Unique element identification number(s) (Integer > 0 or BCD: the second continuation card may have THRU in fields 3 and/or 6 in which case EID2 < EIDi, EIDj < EIDk)
$\bar{T}A$, $\bar{T}B$	Average temperature over the area at end "a" and end "b" (Real)
T'ij	Effective linear gradient in direction i on end j (BAR only, Real)
Tij	Temperatures at point i as defined on the PBAR card(s) at end j. These data are used for stress recovery only (BAR only, Real)

- Remarks:
1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.
 2. If at least one nonzero or nonblank Tij is present, the point temperatures given are used for stress recovery. If no Tij values are given, linear temperature gradients are assumed for stresses.
 3. If the second (and succeeding) continuation card is present, EID1 and elements specified on the second (and succeeding) continuation cards are used. Elements must not be specified more than once.
 4. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

(Continued)

NASTRAN DATA DECK

TEMPRB (Cont.)

5. The effective thermal gradients in the element coordinate system for the BAR element are defined by the following integrals over the cross-section. For end "a" (end "b" is similar):

$$T'_{1a} = \frac{1}{I_1} \int_A T_a(y,z) y \, dA$$

$$T'_{2a} = \frac{1}{I_2} \int_A T_a(y,z) z \, dA$$

where $T_a(y,z)$ is the temperature at point y,z (in the element coordinate system) at end "a" of the BAR. See Section 1.3, Figure 1 for the element coordinate system: I_1 and I_2 are the moment of inertia about the z and y axis respectively. The temperatures are assumed to vary linearly along the length (x -axis). Note that if the temperature varies linearly over the cross-section then T'_{1a} , T'_{1b} , T'_{2a} , and T'_{2b} are the actual gradients.

6. If the element material is temperature dependent, the material properties are evaluated at the average temperature

$$\frac{\bar{T}_A + \bar{T}_B}{2}$$

7. Set ID must be unique with respect to all other LOAD type cards if TEMP(LOAD) is specified in Case Control Deck.

BULK DATA DECK

Input Data Card TF • Dynamic Transfer Function

Description: 1. May be used to define a transfer function of the form

$$(B0 + B1p + B2p^2)u_d + \sum_i (A0(i) + A1(i)p + A2(i)p^2)u_i = 0$$

2. May be used as a means of direct matrix input.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TF	SID	GD	CD	B0	B1	B2			+abc
TF	1	2	3	4.0	5.0	6.0			+ABC
+abc	G(1)	C(1)	A0(1)	A1(1)	A2(1)				+def
+ABC	3	4	5.0	6.0	7.0				+DEF

(etc.)

Field

Contents

SID Set identification number (Integer > 0)

GD,G(i) Grid; scalar or extra point identification numbers (Integer > 0)

CD,C(i) Component numbers (Null or zero for scalar or extra points, any one of the digits 1-6 for a grid point)

B0,B1,B2
A0(i),A1(i),
A2(i) Transfer function coefficients (Real)

- Remarks:
1. The matrix elements defined by this card are added to the dynamic matrices for the problem.
 2. Transfer Function sets must be selected in the Case Control Deck (TFL=SID) to be used by NASTRAN.
 3. The constraint relation given above will hold only if no elements are connected to the dependent coordinate.

4. NASTRAN DATA DECK

The NASTRAN data deck is a text file that contains the input data for the NASTRAN program. It is typically a single file, but can be split into multiple files if the input data is large. The data deck is read by the NASTRAN program and used to perform the finite element analysis. The data deck is organized into sections, each of which contains a specific type of data. The sections are identified by a keyword, which is a three-letter code. The keywords are listed in the following table:

Keyword	Description
GRID	Defines the nodes of the finite element mesh.
CONROD	Defines the rod elements of the finite element mesh.
CONELEM	Defines the element types of the finite element mesh.
CONSTRA	Defines the constraints of the finite element mesh.
LOAD	Defines the loads applied to the finite element mesh.
ANALYSIS	Defines the analysis parameters of the finite element mesh.
RESULTS	Defines the results of the finite element analysis.

The data deck is a text file, so it can be edited using a text editor. The data deck is typically a single file, but can be split into multiple files if the input data is large. The data deck is read by the NASTRAN program and used to perform the finite element analysis. The data deck is organized into sections, each of which contains a specific type of data. The sections are identified by a keyword, which is a three-letter code. The keywords are listed in the following table:

Keyword	Description
GRID	Defines the nodes of the finite element mesh.
CONROD	Defines the rod elements of the finite element mesh.
CONELEM	Defines the element types of the finite element mesh.
CONSTRA	Defines the constraints of the finite element mesh.
LOAD	Defines the loads applied to the finite element mesh.
ANALYSIS	Defines the analysis parameters of the finite element mesh.
RESULTS	Defines the results of the finite element analysis.

BULK DATA DECK

Input Data Card TIC Transient Initial Condition

Description: Defines values for the initial conditions of coordinates used in Transient analysis. Both displacement and velocity values may be specified at independent coordinates of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TIC	SID	G	C	U0	V0				
TIC	1	3	2	5.0	-6.0				

<u>Field</u>	<u>Contents</u>
SID	Set identification number (Integer > 0)
G	Grid or scalar or extra point identification number (Integer > 0)
C	Component number (Null or zero for scalar or extra points, any <u>one</u> of the digits 1-6 for a grid point)
U0	Initial displacement value (Real)
V0	Initial velocity value (Real)

- Remarks:
1. Transient initial condition sets must be selected in the Case Control Deck (IC=SID) to be used by NASTRAN.
 2. If no TIC set is selected in Case Control Deck, all initial conditions are assumed zero.
 3. Initial conditions for coordinates not specified on TIC cards will be assumed zero.
 4. Initial conditions may be used only in direct formulation.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TLØAD1 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \{A F(t - \tau)\}$$

for use in transient response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD1	SID	L	M		TF				
TLØAD1	5	7	9		13				

Field

Contents

SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set or a thermal load set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer \geq 0)
TF	Identification number of TABLEDi card which gives $F(t - \tau)$ (Integer > 0)

Remarks:

1. If M is zero, τ will be zero.
2. Field 5 must be blank.
3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
4. TLØAD1 loads may be combined with TLØAD2 loads only by specification on a DLØAD card. That is, the SID on a TLØAD1 card may not be the same as that on a TLØAD2 card.
5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.
6. Field 3 may reference sets containing QHBDY, QBDY1, QBDY2, QVECT, and QVØL cards when using the heat transfer option.
7. If the heat transfer option is used, the referenced QVECT data card may also contain references to functions of time, and therefore A may be a function of time.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TLØAD2 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \begin{cases} \{0\}, & \tilde{t} < 0 \text{ or } \tilde{t} > T2 - T1 \\ \{A \tilde{t}^B e^{\tilde{C}\tilde{t}} \cos(2\pi F\tilde{t} + P)\}, & 0 \leq \tilde{t} \leq T2 - T1 \end{cases}$$

for use in transient response problems where $\tilde{t} = t - T1 - \tau$.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD2	SID	L	M		T1	T2	F	P	abc
TLØAD2	4	10	7		2.1	4.7	12.0	30.0	+12
+bc	C	B							
+12	2.0	3.0							

Field

Contents

SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set or a thermal load set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer ≥ 0)
T1	Time constant (Real ≥ 0.0)
T2	Time constant (Real, $T2 > T1$)
F	Frequency in cycles per unit time (Real ≥ 0.0)
P	Phase angle in degrees (Real)
C	Exponential coefficient (Real)
B	Growth coefficient (Real)

Remarks:

1. If M is zero, τ will be zero.
2. Field 5 must be blank.
3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
4. TLØAD2 loads may be combined with TLØAD1 loads only by specification on a DLØAD card. That is, the SID on a TLØAD2 card may not be the same as that on a TLØAD1 card.
5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.

NASTRAN DATA DECK

TLØAD2 (Cont.)

6. Field 3 may reference load sets containing QHBDY, QBDY1, QBDY2, QVECT, and QVØL cards when using the heat transfer option.
7. If the heat transfer option is being used, the referenced QVECT load card may also contain references to functions of time, and therefore A may be a function of time.

BULK DATA DECK

Input Data Card TRANS

Component Substructure Transformation Definition

Description: Defines the location and orientation of the component substructure basic coordinate system axes relative to the basic coordinate system of the substructure formed as a result of the substructure COMBINE operation. The translation and rotation matrices are defined by specifying the coordinates of three points A, B, C. The coordinates of points A, B, C must be expressed on this card in the basic coordinate system of the resultant combined substructure as follows:

- A - defines the location of the origin of the basic coordinate system of the component substructure.
- B - defines the location of a point on the z axis of the basic coordinate system of the component substructure.
- C - defines the location of a point in the positive x side of the xz plane of the basic coordinate system of the component substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TRANS	CID		A1	A2	A3	B1	B2	B3	abc
TRANS	1		0.0	0.0	0.0	0.0	-0.5	10.0	ABC
+bc	C1	C2	C3						
+BC	0.0	10.0	0.5						

Field

Contents

CID	Set identification number (Integer > 0)				
<table border="0"> <tr> <td>A1, A2, A3</td> <td rowspan="3" style="font-size: 3em; vertical-align: middle;">}</td> <td rowspan="3">Coordinates of the points defining system as described above.</td> </tr> <tr> <td>B1, B2, B3</td> </tr> <tr> <td>C1, C2, C3</td> </tr> </table>	A1, A2, A3	}	Coordinates of the points defining system as described above.	B1, B2, B3	C1, C2, C3
A1, A2, A3	}			Coordinates of the points defining system as described above.	
B1, B2, B3					
C1, C2, C3					

- Remarks:
- Continuation card must be present.
 - Coordinates A, B, C are given in BASIC coordinate system of the result substructure.
 - The value of CID must be unique with respect to all other TRANS data cards.
 - Transformation sets for a whole substructure must be selected in the Substructure Control Deck (TRANS=SID) to be used by NASTRAN. Note that 'TRANS' is a subcommand of the substructure COMBINE command.
 - Transformation of individual grid points in a substructure prior to combining them is requested by the GTRAN Bulk Data card which references the TRANS information.

NASTRAN DATA DECK

BULK DATA DECK

Input Data Card TSTEP Transient Time Step

Description: Defines time step intervals at which solution will be generated and output in Transient Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TSTEP	SID	N(1)	DT(1)	NØ(1)					+abc
TSTEP	2	10	.001	5					+ABC
+abc		N(2)	DT(2)	NØ(2)					+def
+ABC		9	0.01	1					+DEF

(etc.)

Field

Contents

SID	Set identification number (Integer > 0)
N(i)	Number of time steps of value DT(i) (Integer ≥ 2)
DT(i)	Time increment (Real > 0.0)
NØ(i)	Skip factor for output (Every NØ(i) th step will be saved for output) (Integer > 0)

Remarks: TSTEP cards must be selected in the Case Control Deck (TSTEP=SID) in order to be used by NASTRAN.

NASTRAN DATA DECK

NASTRAN DATA DECK

2.5 USER'S MASTER FILE

As a means of aiding the user in handling the large (several boxes of cards) Bulk Data Decks which are typical of NASTRAN problems, the User's Master File is provided for storage of many Bulk Data Decks on a single tape. There are many advantages to using a Master File. For a problem that several investigators are concurrently studying, the User's Master File provides a convenient common source of data. Standardization is easy to impose since there can be only one legitimate structural model deck for any given problem. When various parts of a structure are being analyzed separately, they may all be placed on the same User's Master File for ease of use. Errors due to card handling equipment (and people!) are sharply reduced since a several box input deck is reduced to a few cards. Finally, the convenience to the user in submitting jobs should be emphasized (run decks can be hand-carried!).

2.5.1 Use of User's Master File

Functionally, the User's Master File exhibits all of the properties of an Old Problem Tape (ØPTP) which would result if a job were terminated after the NASTRAN preface; only the control cards used are different. Thus the User's Master File (UMF) becomes an alternate source of bulk data input to NASTRAN which may be modified in identically the same way as bulk data is changed during a modified restart. Since the UMF is used as an alternate ØPTP functionally, only one or the other may appear in a run. The UMF, then, is used only for an initial run and may not be used in conjunction with a restart. The checkpoint feature may be used with a UMF run, however, and the resulting New Problem Tape (NPTP) may be used as an ØPTP in a subsequent restart.

In describing the use of the User's Master File, the UMF control cards will be contrasted with their ØPTP counterparts. In place of the setup card for the ØPTP tape (see Chapter 5 of the Programmer's Manual for a discussion of these machine and installation dependent NASTRAN driver control cards), use a setup card for the selected UMF tape. In place of the restart dictionary in the Executive Control Deck, use the card

UMF k_1, k_2

described in Section 2.2.1, which selects Bulk Data Deck k_2 from UMF tape k_1 to use in the current execution.

NASTRAN DATA DECK

2.5.2 Using the User's Master File Editor

To assist the NASTRAN user in creating and maintaining User's Master Files, an auxiliary NASTRAN preface module, the User's Master File Editor, is provided. The functions performed by the Editor are:

1. Create a New User's Master File (NUMF) from Bulk Data Decks supplied by the user.
2. List and/or punch Bulk Data Decks from an already existing UMF.
3. Edit Bulk Data Decks (which may be modified) from an old UMF onto a NUMF.

Bulk Data Decks must be acceptable to the NASTRAN preface (XSORT and IFP) to be accepted by the Editor.

The executive control card that causes NASTRAN to execute as the User's Master File Editor is UMFEDIT. When in the Editor mode, NASTRAN executes only the preface. A separate run is required to use a User's Master File generated by the Editor. Preface module UMFEDT, which is where the User's Master File Editor actions occur, reads data cards from the System Input Stream which are used to control Editor activity. Some of these data cards precede the Bulk Data Deck being processed while others follow. The remainder of this section will be devoted to describing these cards and the action caused by them. Section 2.5.3 gives some rules to be followed when making up data cards for the Editor. Several examples will then be given in Section 2.5.4 to illustrate the functions performed by the User's Master File Editor.

Table 1 shows the Editor data cards and describes the action taken for each one. Three classes are described, depending on the tapes used. The cards are free-field format as are the executive control cards and case control cards previously described. The symbolic quantities tid and pid are each up to 8 arbitrarily selected integers chosen by the user who causes the User's Master File to be created. Table 2 shows a summary of Editor control cards.

When a New User's Master File (NUMF) is created, the User's Master File Editor (UMFEDIT) punches the Executive Control cards that are needed to read the decks from the newly created master file. The UMFEDIT automatically punches one UMF Executive Control card for each Bulk Data Deck that is written on the NUMF and lists it in a table of contents.

USER'S MASTER FILE

2.5.3 Rules for the User's Master File Editor

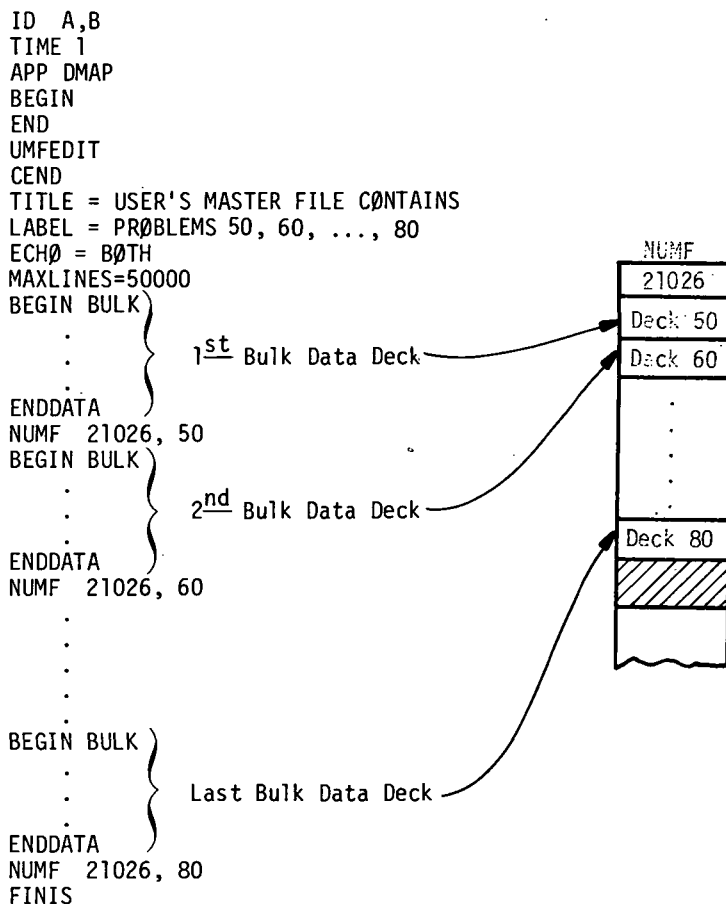
1. The tape identification number, tid, and the problem identification number, pid, are positive integers selected by the user. The only exception to this is that pid may be zero if the UMF card is being used only to specify a value for tid or to indicate a new deck rather than an alter set.
2. The tape identification number, tid, must be the same for all decks on a single UMF.
3. Only one pass is made while either reading the UMF or writing the NUMF. Sequential processing requests are thereby required. This means that the problem identification numbers must form an increasing sequence corresponding to the order of the decks.
4. A corollary to 2 is that a deck to be inserted between two decks on an existing UMF must be given a problem identification number whose value "lies between" the values of the problem identification numbers for the two UMF decks. Thus, an initial numbering sequence such as 10, 20, 30, ... is recommended.
5. Most NASTRAN users develop the habit of "storing" data cards not needed for a given run behind the ENDDATA card where they are normally ignored. This must not be done when using the Editor since it reads data from this position. Data cards following the FINIS card are ignored, however.

2.5.4 Examples of User's Master File Editor Usage

Several examples of User's Master File Editor usage are given in this section. The user is well-advised to study these examples both from the standpoint of understanding the functioning of the Editor and from the standpoint of learning how to use this NASTRAN feature. A symbolic representation of the contents of the UMF and/or NUMF used in each example is given along with an explanation of specific items of interest. These examples illustrate all of the capability of the User's Master File Editor.

NASTRAN DATA DECK

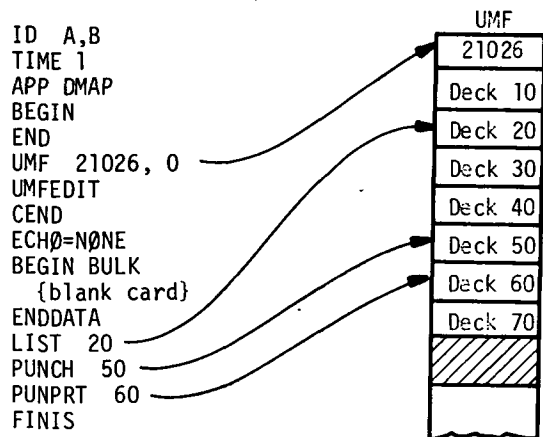
Example 1. Create a User's Master File



- Notes:
1. A tape must be set up for NASTRAN file NUMF.
 2. A tape must not be set up for NASTRAN file UMF.
 3. The DMAP sequence will not be used but must appear in the Executive Control Deck.
 4. ECHO = BOTH is recommended since the unsorted Bulk Data Deck is available only during the run used to create the User's Master File. The sorted echo is needed in order to make alterations to the bulk data when using the User's Master File in a NASTRAN run.
 5. Note that the tape identification number, tid, is the same on all of the NUMF cards.
 6. Note that the problem identification numbers, pid, are increasing according to the data deck order.

USER'S MASTER FILE

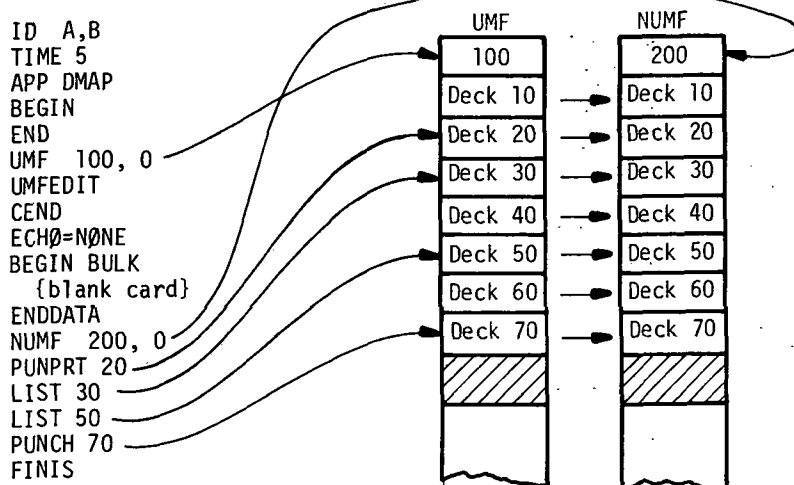
Example 2. List and/or punch selected decks from a User's Master File



- Notes:
1. A tape containing the proper User's Master File must be set up on NASTRAN file UMF.
 2. A tape must not be set up for NASTRAN file NUMF.
 3. The DMAP sequence will not be used but must appear in the Executive Control Deck.
 4. The dummy Bulk Data Deck consisting of a single blank card will not be used but must appear.
 5. ECHO = NONE is recommended to suppress printout of the dummy Bulk Data Deck. This has no effect on the User's Master File Editor.
 6. The zero value of pid on the UMF card is required since only tid is being used in this application.
 7. The LIST, PUNCH, and PUNPRT cards must be sequenced such that the pid values form an increasing sequence.
 8. The above requests will cause a sorted Bulk Data Deck echo to be made for decks 20 and 60; decks 50 and 60 will be punched.

NASTRAN DATA DECK

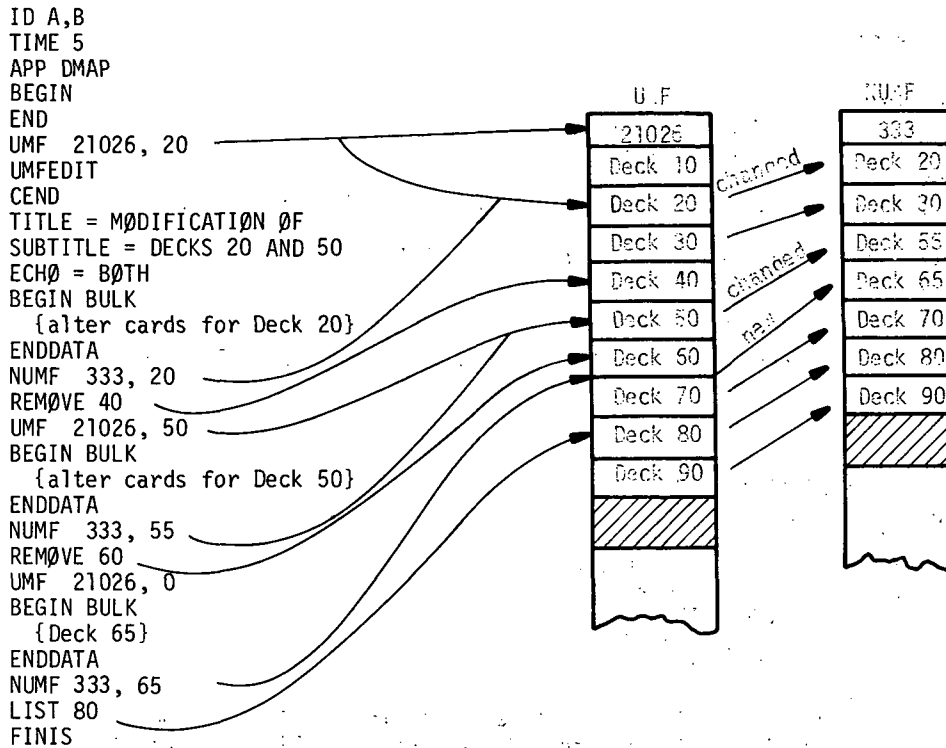
Example 3. Copy a User's Master File while listing and/or punching selected decks.



- Notes:
1. A tape containing the User's Master File to be copied must be set up on NASTRAN file UMF.
 2. A tape must be set up on NASTRAN file NUMF.
 3. The DMAP sequence is not used but must appear in the Executive Control Deck.
 4. The dummy Bulk Data Deck consisting of a single blank card will not be used but must appear.
 5. ECHO = NONE is recommended to suppress printout of the dummy Bulk Data Deck. This has no effect on the User's Master File Editor.
 6. The zero value of pid on the UMF card is required since only tid is being used in this application.
 7. The zero value of pid on the NUMF card is not used. This card is used to specify tid for the NUMF. If the NUMF card were absent, the same tid would be put on the NUMF as existed on the UMF.
 8. The LIST, PUNCH, and PUNPRT cards must be sequenced such that the pid values form an increasing sequence.
 9. The above requests will cause a sorted Bulk Data Deck echo to be made for decks 20, 30, and 50; decks 20 and 70 will be punched.
 10. All of the decks contained on the UMF will be copied onto the NUMF tape. The tape identification number will be different as explained in note 7.

USER'S MASTER FILE

Example 4. Edit a User's Master File



- Notes:
1. A tape containing the User's Master File to be edited must be set up on NASTRAN file UMF.
 2. A tape must be set up on NASTRAN file NUMF.
 3. The DMAP sequence is not used but must appear in the Executive Control Deck.
 4. ECHO = BOTH is recommended since the alter cards are available only during the run used to perform the edit. The sorted echo is needed for those decks being altered in order to make further alterations to the bulk data when using the newly created User's Master File in a NASTRAN run. Decks not being altered will not be echoed as a result of the ECHO = BOTH card. Such decks may be echoed as they are copied as shown in the example for Deck 80.
 5. The pid values must form an increasing sequence.
 6. The requests in the above example will cause listings to be generated for deck 80; no decks will be punched.
 7. Decks 30, 70, 80, and 90 will be copied onto the NUMF with no changes.
 8. Decks 10, 40, and 60 will be removed (i.e., not copied onto the NUMF).
 9. Decks 20 and 50 will be modified. In addition the problem identification number of Deck 50 will be changed to 55.
 10. Deck 65 will be added.
 11. Deck 10 is removed because it appears prior to the first call to the Editor. This may be avoided by using a pid of zero and a dummy Bulk Data Deck as shown in Example 3.

NASTRAN DATA DECK

Table 1. User's Master File Editor Control Card Actions.

I. UMF Only is Present

- A. FINIS
 - 1. Terminate run.
- B. BEGIN BULK (Not Allowed)
- C. REMOVE pid (Not Allowed)
- D. LIST pid
 - 1. Skip UMF forward to pid and list the Bulk Data Deck on the printer.
- E. PUNCH pid
 - 1. Skip UMF forward to pid and punch the Bulk Data Deck on the punch.
- F. UMF tid, pid (Not Allowed)
- G. NUMF tid, pid (Not Allowed)
- H. PUNPRT pid
 - 1. Skip UMF forward to pid and then list and punch the Bulk Data Deck.

II. NUMF Only is Present

- A. FINIS
 - 1. Write end-of-file on NUMF.
 - 2. Terminate run.
- B. BEGIN BULK
 - 1. Process the next Bulk Data Deck.
- C. REMOVE pid (Not Allowed)
- D. LIST pid (Not Allowed)
- E. PUNCH pid (Not Allowed)
- F. UMF tid, pid (Not Allowed)
- G. NUMF tid, pid
 - 1. If first entry to Editor, write tape identification file on NUMF.
 - 2. Add preceding Bulk Data Deck to NUMF and automatically punch and list the UMF card for use with UMF.
- H. PUNPRT pid (Not Allowed)

III. Both UMF and NUMF are Present

- A. FINIS
 - 1. Copy any remaining Bulk Data Decks from UMF to NUMF.
 - 2. Write end-of-file on NUMF.
 - 3. Terminate run.
- B. BEGIN BULK
 - 1. Process the next Bulk Data Deck which may be a new deck or a modified deck from the UMF.
- C. REMOVE pid
 - 1. Copy UMF onto NUMF up to indicated deck.
 - 2. Skip indicated deck on UMF.
- D. LIST pid
 - 1. Copy UMF onto NUMF through indicated deck.
 - 2. List indicated Bulk Data Deck on printer.
- E. PUNCH pid
 - 1. Copy UMF onto NUMF through indicated deck.
 - 2. Punch indicated Bulk Data Deck on printer.
- F. UMF tid, pid
 - 1. Copy UMF onto NUMF up to indicated deck. (Must be immediately followed by BEGIN BULK card.)
- G. NUMF tid, pid
 - 1. If first entry to Editor, write tape identification file on NUMF.
 - 2. Copy UMF onto NUMF up to deck with identification greater than pid.
 - 3. Add preceding Bulk Data Deck to NUMF and automatically punch and list the UMF card for use with UMF.
- H. PUNPRT pid
 - 1. Copy UMF onto NUMF through indicated deck.
 - 2. List indicated Bulk Data Deck on printer.
 - 3. Punch indicated Bulk Data Deck on punch.

USER'S MASTER FILE

Table 2. Summary of User's Master File Editor Control Cards.

LIST pid	List the problem deck from UMF or copy the problem deck from UMF onto NUMF and list it.
NUMF tid, pid	Add problem deck to NUMF, list it and punch UMF card.
PUNCH pid	Punch the problem deck from UMF or copy the problem deck from UMF onto NUMF and punch it.
PUNPRT pid	Punch and print the problem deck from UMF or copy the problem deck from UMF onto NUMF and punch and print it.
REMOVE pid	Copy problem decks from UMF onto NUMF up to pid and skip over problem pid.
UMF tid, pid	Copy UMF problem deck onto NUMF, list it and punch UMF card.

NASTRAN DATA DECK

2.5.5 NASTRAN Demonstration Problems

The standard set of NASTRAN Demonstration Problems are each identified by a UMF tid, pid card. Thus, to run a demonstration problem, either use the Executive and Case Control driver decks provided or alter them and then add the bulk data deck from the UMF. Bulk data cards can be deleted with the / card or others can be added by referring to the sorted Bulk Data Deck Card number. See the NASTRAN Demonstration Problems Manual for the appropriate UMF number.

NASTRAN DATA DECK

2.6 USER GENERATED INPUT

It may happen that a user will want to take a problem previously run on another program and run it using NASTRAN. In many instances, this provides the user with the quickest means of familiarizing himself with NASTRAN since he is running a problem which he understands intimately. Also, he may wish to extend his analysis of some previously analyzed problem into regions which previous programs would not allow. In either event, he is faced with the problem of Input Data conversion.

The simplest way to convert structural model data is to write a small FORTRAN (or other language) program to read in the data cards composing the input data deck for the previous program and punch a new NASTRAN Bulk Data Deck. Usually, the information is in a one to one correspondence, and this procedure is quite straight forward, requiring only a minimal knowledge of programming. While a large deck of cards may result, by using the User's Master File feature described in Section 2.5, the amount of large deck handling may be minimized.

2.6.1 Utility Module INPUT Usage

NASTRAN has implemented one data generating utility module within its existing structure for specific cases. General characteristics of the INPUT module are as follows:

1. INPUT allows the user of NASTRAN to generate the majority of the bulk data cards for a number of selected test problems without having to actually input the physical cards into the Bulk Data Deck.
2. The test problems for which partial data are generated by INPUT are:
 - a. N x N Laplace Network from scalar elements
 - b. W x L Rectangular Frame from BAR elements or ROD elements
 - c. W x L Rectangular Array of QUAD1 elements
 - d. W x L Rectangular Array of TRIA1 elements
 - e. N - segment string from scalar elements
 - f. N - cell beam made from BAR elements
 - g. N - scalar point full matrix with optional unit loading

These problem types are described separately in the following sections.

NASTRAN DATA DECK

3. To use INPUT variations of the following alter deck must be used:

```
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT,      ,,,,/G1,G2,----,G5/C,N,a/C,N,b/C,N,b $
EQUIV G1,GEØM1/TRUE / G2,GEØM2/TRUE----/ G5,GEØM5/TRUE $
ENDALTER
```

The specific data blocks that need be included depend on the particular problem as do the parameter values. Examples for each problem type will be given.

4. Data cards are read by INPUT from the System Input File using FØRTRAN I/Ø, each card containing up to 10 eight column fields. Remember to right-justify this data. The required data are described in each problem type description.

5. The INPUT data card(s) follow the ENDDATA card. Do not "store" other data that is not intended to be used by the INPUT module. Note that if the Univac 1108 is used, a system control card @XQT *NASTRAN.LINK2 must be inserted between the ENDDATA and INPUT data card(s).

6. Several sample problems were run as part of checkout. The input for these runs are available as examples of INPUT usage.

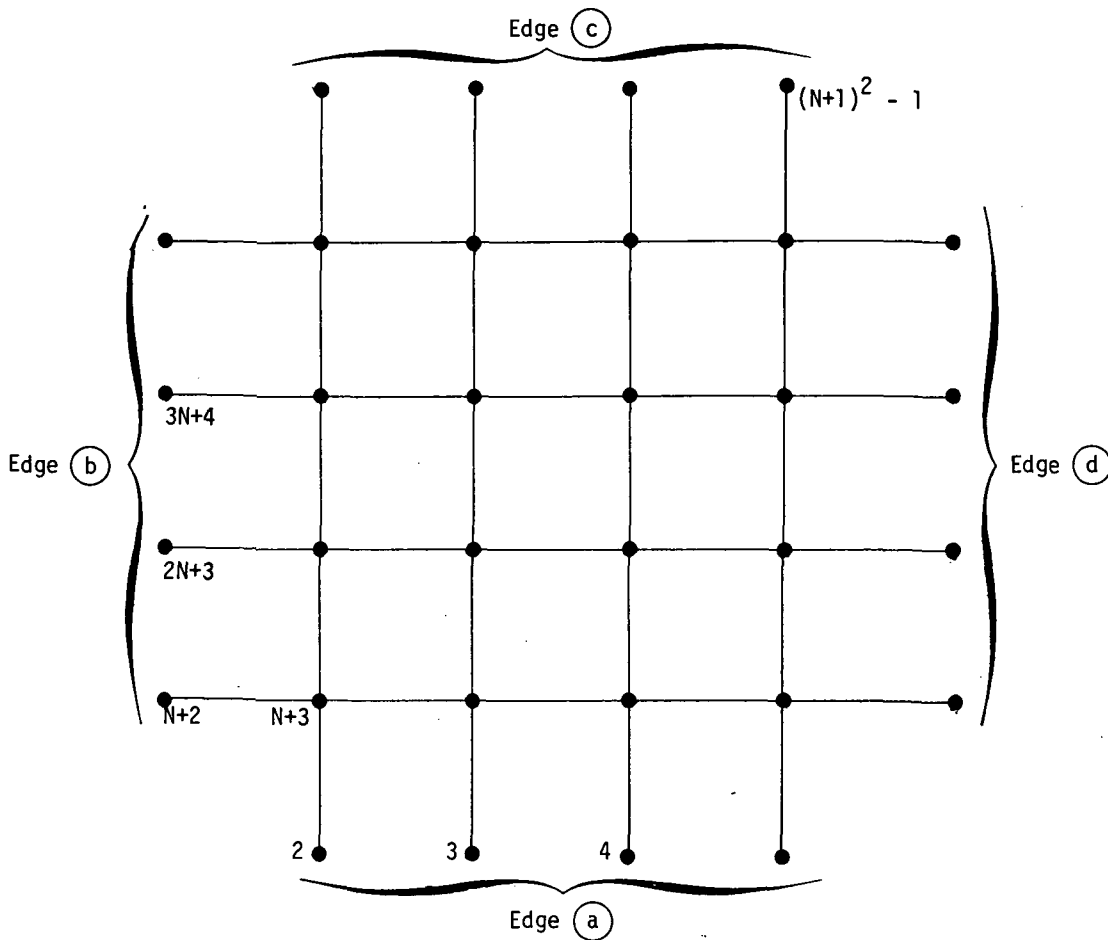
7. Restart tables are not effective with respect to "cards" generated by INPUT since the preface is unaware of their existence.

8. The INPUT data generator feature is restrictive. It can only be used in the circumstances illustrated. The user may employ the INPUT module as described but merging of user data with INPUT data is not supported. As an example, single point constraints may be defined either in the bulk data deck or in the INPUT module data deck but not both places in an attempt to combine them. Thus if SPC cards are defined in the bulk data deck, then the G4 data block will not be generated and GEØM4 must not be equivalenced to G4.

2.6.1.1 Laplace Circuit (a=1, b=1,2 or 3, c is not used)

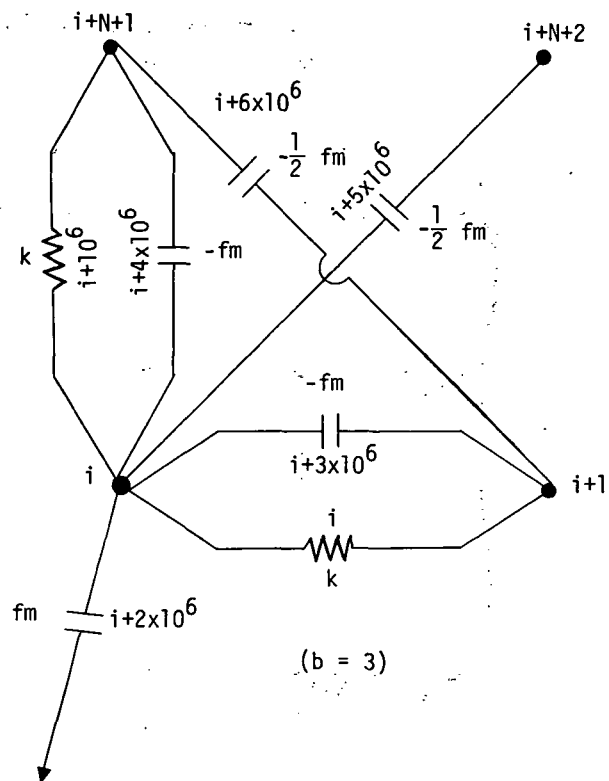
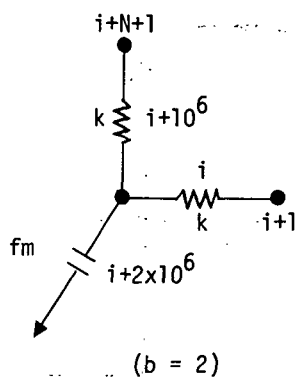
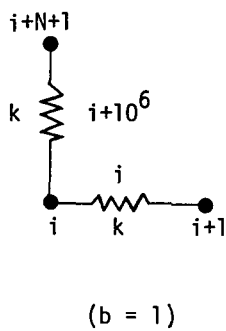
INPUT generates CELAS4, SPC (for b=1), and CMASS (for b=2,3) cards for the circuit shown.

USER GENERATED INPUT



The scalar point id's are 1 through $(N+1)^2$ except for 1, $N+1$, $N(N+1)+1$, and $(N+1)^2$. For $b = 2$ or 3, all edge points are replaced with ground. The scalar elements generated are shown below for each value of b for a typical cell. Elements between edge points are not generated.

NASTRAN DATA DECK



a. Data Card

- | | | | |
|---|---|--------|--|
| 1 | N | (I8) | N^2 = no. of cells |
| 2 | k | (E8.0) | Spring stiffness |
| 3 | U | (E8.0) | Enforced displacement along edge (b) (b = 1) |
| 3 | m | (E8.0) | Mass (b = 2,3) |
| 4 | f | (E8.0) | Coupling fraction (b = 3 only) |

b. Options

- b {
- = 1, statics. Use statics (Rigid Format D-1) to solve $\nabla^2 u = 0$ with boundary conditions $u = 0$ along (a), (c) and (d), $u = U$ along (b). G2 and G4 are both used. No masses are generated.
 - = 2, no mass coupling. Use real eigenvalue analysis (Rigid Format D-3) to obtain the eigenvalues of a square membrane ($\nabla^2 u = \frac{\partial^2 u}{\partial t^2}$) where the theoretical solutions for $N \rightarrow \infty$ are given by
$$f_{ij} = \frac{1}{N} \{i^2 + j^2\}^{1/2}; \quad i, j = 1, 2, \dots$$
U is ignored. **Only** G2 is used. Diagonal masses only are generated.
 - = 3, mass coupling. Same as where the diagonal masses are m. The horizontal and vertical masses are -fm; the cross diagonal masses are $-\frac{1}{2}$ fm.

c. Notes

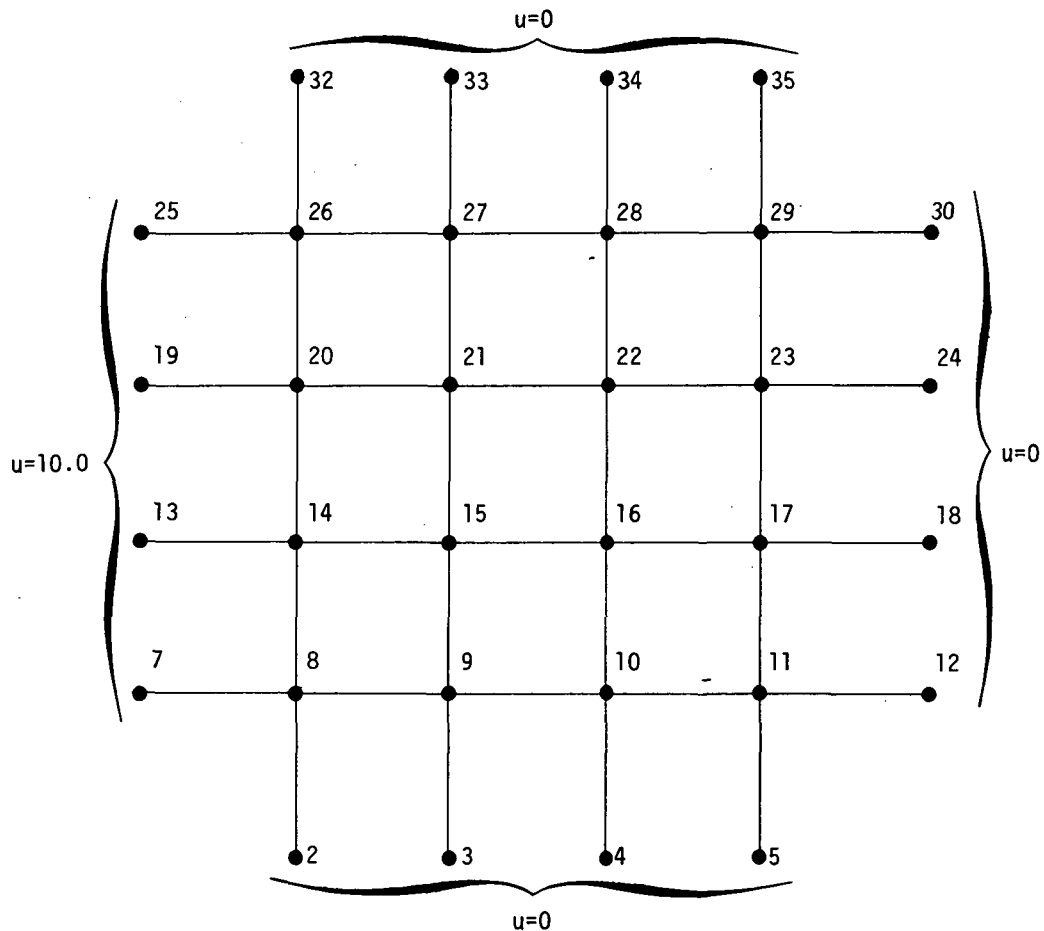
- (1) For $b = 1$, $SPR = 1000+N$ must be selected in Case Control Deck.

NASTRAN DATA DECK

```

ID INPUT,CASE1
TIME 30
APP DISP
SOL 1,3
ALTER 1
PARAM //C,N,NOP/V,N,TRUE=-1 $
INPUT, ,,,,/G2,,G4,/C,N,1/C,N,1 $
EQUIV G2,GEOM2/TRUE / G4,GEOM4/TRUE $
ENDALTER
CEND
ECHO=BOTH
TITLE=TEST OF UTILITY MODULE INPUT
SUBTITLE=LAPLACE CIRCUIT
LABEL=STATICS
SPC=1005
OUTPUT
DISP=ALL
BEGIN BULK
{blank card}
ENDDATA
    
```

5 1.0 10.0

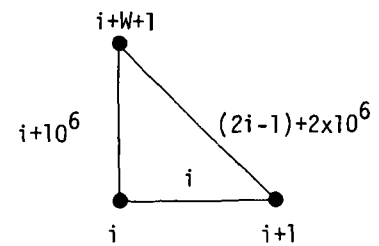
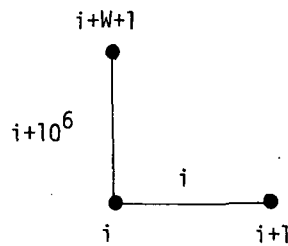
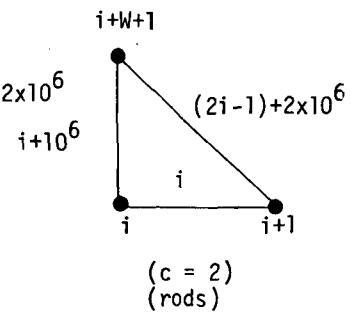
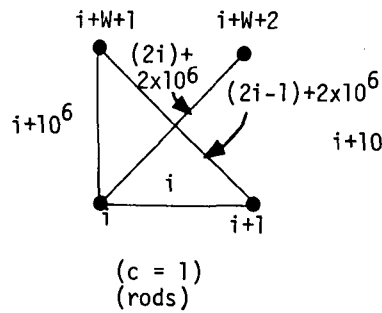
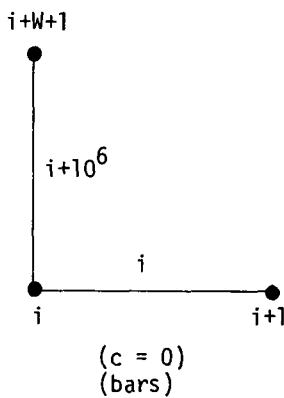
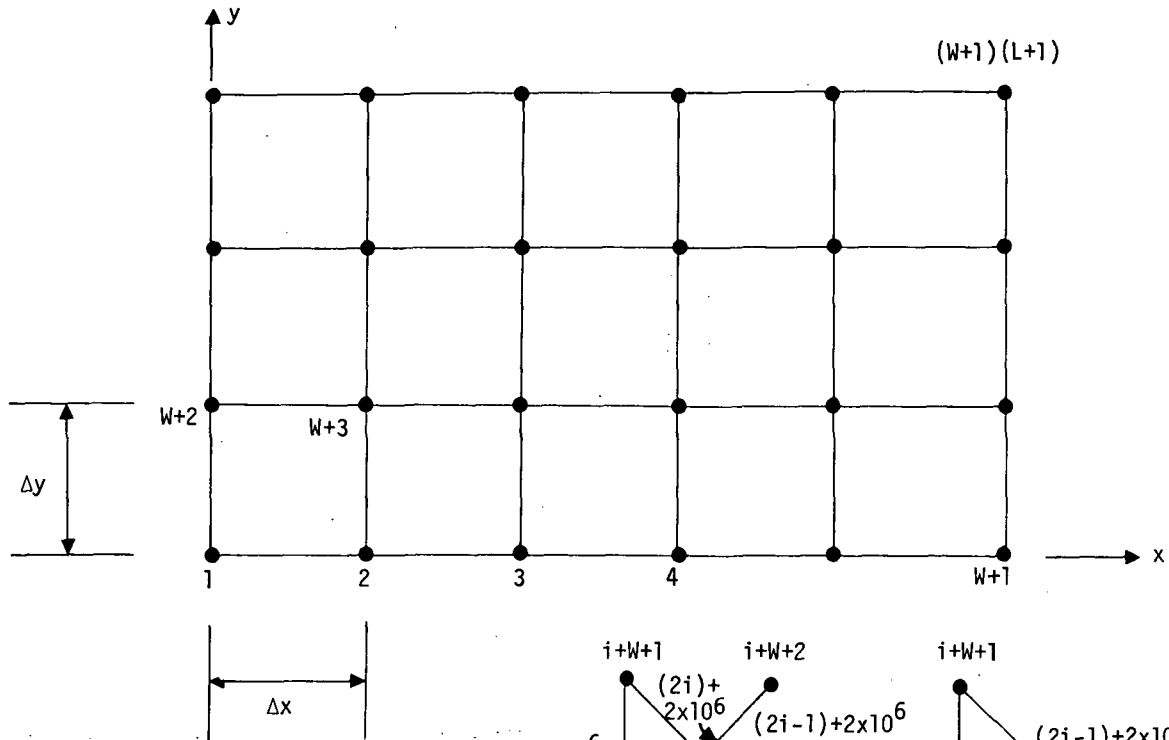


Lines indicate scalar springs

USER GENERATED INPUT

2.6.1.2 Rectangular Frame made from BAR's or ROD's ($a=2$, $b=1,2,3$ or 4 , $c=0,1,2$ or 3)

INPUT generates GRID, CBAR or CRØD and SEQGP cards for the rectangular frame shown.



cells other than on left edge or bottom ($c=3$) (rods)

cells on left edge or bottom

NASTRAN DATA DECK

a. Data Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	Δx	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	P	(I8)	Permanent single-point constraints

b. Options (SEQGP cards)

b	{	=1, Regular Banding (no SEQGP cards)
		=2, Double Banding
		=3, Active Columns
		=4, Reverse Double Banding
c	{	=0, Bars
		=1, Rods with both diagonals
		=2, Rods with UL - LR diagonals
		=3, Rods - statically determinate

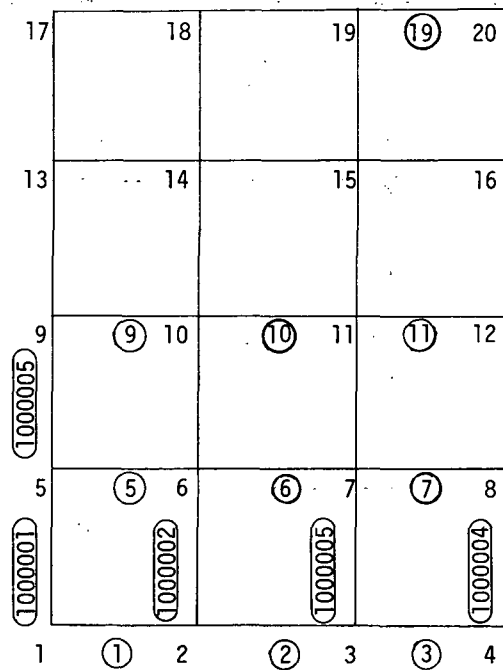
c. Notes

(1) A PBAR card with PID of 101 must be supplied as part of the bulk data for $c = 0$; for $c \neq 0$, this is a PRØD card.

USER GENERATED INPUT

```

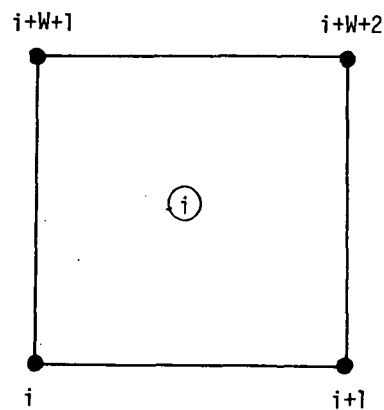
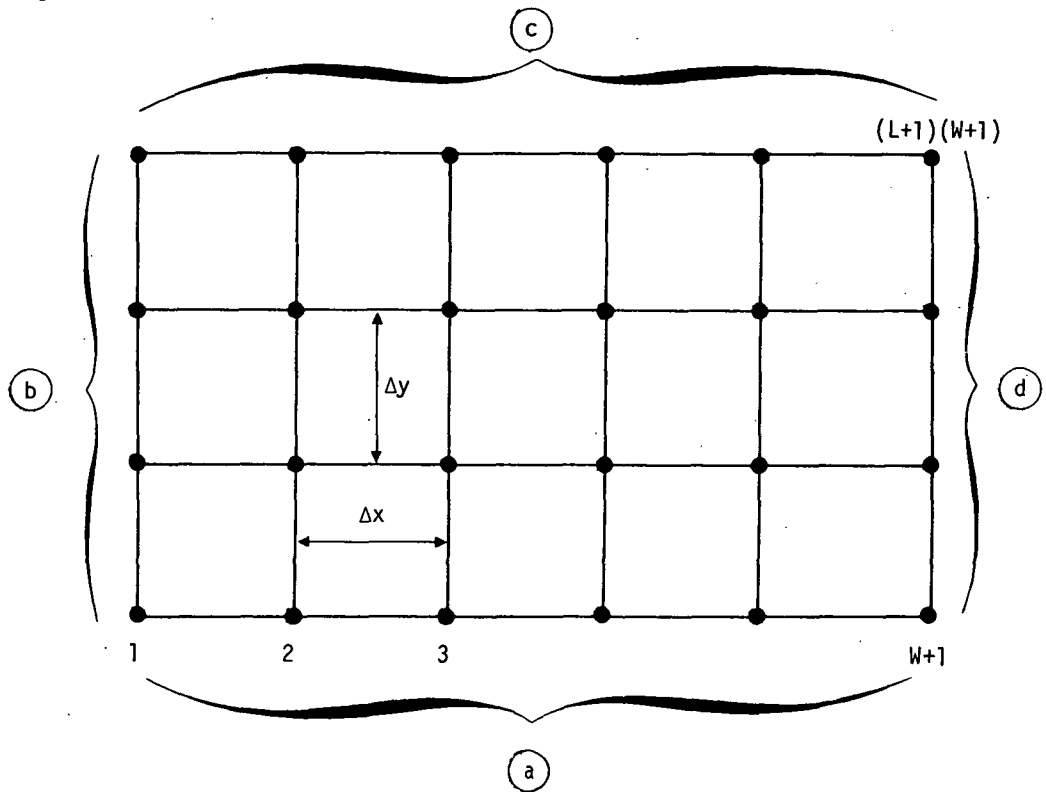
ID INPUT, CASE2
TIME 30
APP DISP
SOL 1,3
ALTER 1
PARAM //C,N,NOP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,,/C,N,2/C,N,1 $
EQUIV G1,GEOM1/TRUE / G2,GEOM2/TRUE $
ENDALTER
CEND
ECH0=BOTH
TITLE=TEST OF UTILITY MODULE INPUT
SUBTITLE=RECTANGULAR FRAME FROM BARS
LABEL=REGULAR BANDING
SPC=1
LOAD=1
OUTPUT
SET 101 = 1,4,17,20
DISP=101
BEGIN BULK
FORCE      1      20      0      1.0      1.0      0.0      0.0
MAT1       7      1.0     1.0
PBAR      101     7      1.0     2.0     4.0     8.0
SPC        1      1     1234     0.0      4      23      0.0
ENDDATA
3      4      1.0     2.0     345
    
```



NASTRAN DATA DECK

2.6.1.3 Rectangular Plate made from QUAD1's (a=3, b=1,2,3 or 4, c is not used)

INPUT generates GRID, CQUAD1, SEQGP and SPC (if requested) cards for the rectangular grid work shown.



USER GENERATED INPUT

a. Data Deck (2 cards required)

First Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	ΔX	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	IP	(I8)	Permanent constraints
6	θ	(E8.0)	Material orientation angle in degrees

Second Card

1	IY0	(I8)	SPC's on $y = 0$
2	IX0	(I8)	SPC's on $x = 0$
3	IYL	(I8)	SPC's on $y = L \cdot \Delta y$
4	IXW	(I8)	SPC's on $x = W \cdot \Delta x$
5	IØX	(I8)	ØMIT's in x-direction
6	IØY	(I8)	ØMIT's in y-direction

b. Options (SEQGP cards)

b	{	=1, Regular banding (no SEQGP cards)
		=2, Double banding
		=3, Active banding
		=4, Reverse double banding

c. Notes

- (1) If IP, IY0, IX0, IYL and IXW are all zero, G4 will be purged.
- (2) A PQUAD1 card with PID = 101 must be included in the Bulk Data.
- (3) If SPC's are generated the set ID will be 1000NX + NY.

NASTRAN DATA DECK

```

ID INPUT, CASE3
TIME 30
APP DISP
SOL 1,3
ALTER 1
PARAM //C,N,NOP/V,N,TRUE=-1 $
INPUT, ,,,/G1,G2,,G4,/C,N,3/C,N,1 $
EQUIV G1,GEOM1/TRUE / G2,GEOM2/TRUE / G4,GEOM4/TRUE $
ENDALTER
CEND
ECH0=BOTH
TITLE=TEST OF UTILITY MODULE INPUT
SUBTITLE=RECTANGULAR PLATE MADE FROM CQUAD1'S
LABEL=STATICS          SIMPLE SUPPORTS          REGULAR BAND

```

SPC=5005

LOAD=1

OUTPUT

DISP=ALL

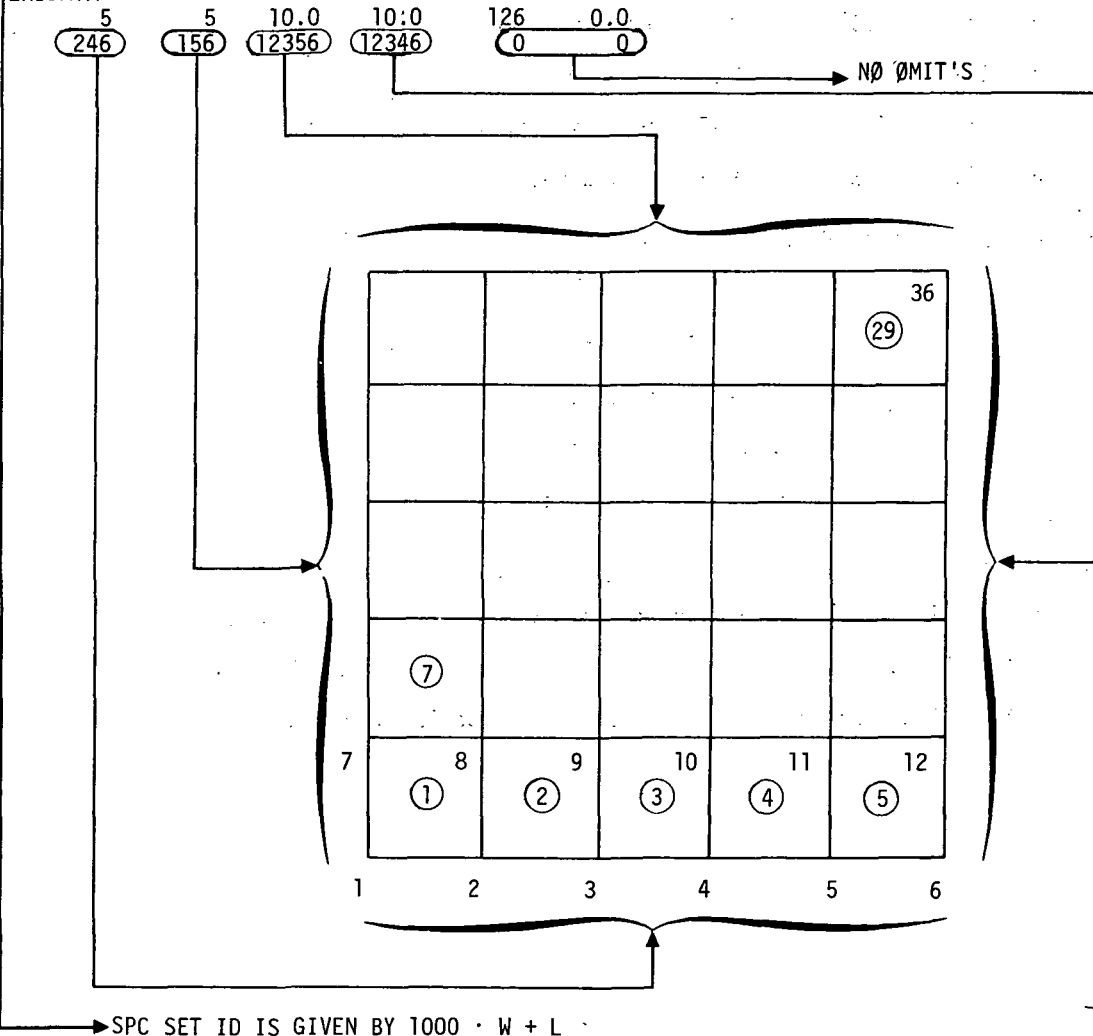
BEGIN BULK

FORCE 1 1 0 1.0 0.0 0.0 1.0

MAT1 7 1.0 1.0

PQUAD1 101 7 1.0 7 2.0 7 4.0

ENDDATA

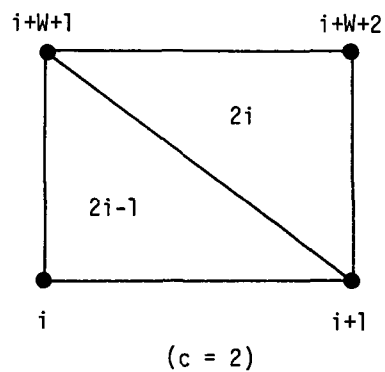
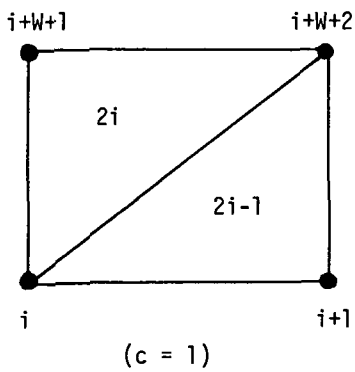
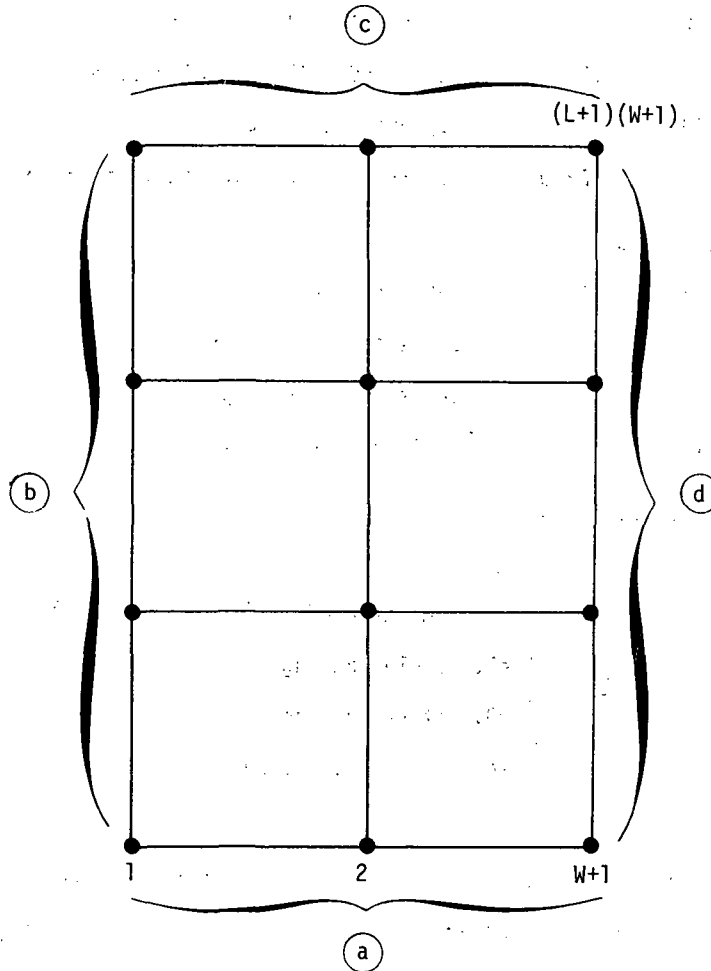


SPC SET ID IS GIVEN BY 1000 * W + L

USER GENERATED INPUT

2.6.1.4 Rectangular Plate made from TRIA1's ($a=4$, $b=1,2,3$ or 4 , c is not used)

INPUT generates GRID, CTRIA1 and SPC (if requested) cards for the rectangular grid work shown.



NASTRAN DATA DECK

a. Data Deck (2 cards required)

First Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	ΔX	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	IP	(I8)	Permanent constraints
6	θ	(E8.0)	Material orientation angle in degrees

Second Card

1	IY0	(I8)	SPC's on $y = 0$
2	IX0	(I8)	SPC's on $x = 0$
3	IYL	(I8)	SPC's on $y = L \cdot \Delta y$
4	IXW	(I8)	SPC's on $x = W \cdot \Delta x$

b. Options (SEQGP cards)

b	{	=1, Regular banding (no SEQGP cards)
		=2, Double banding
		=3, Active banding
		=4, Reverse double banding

c. Notes

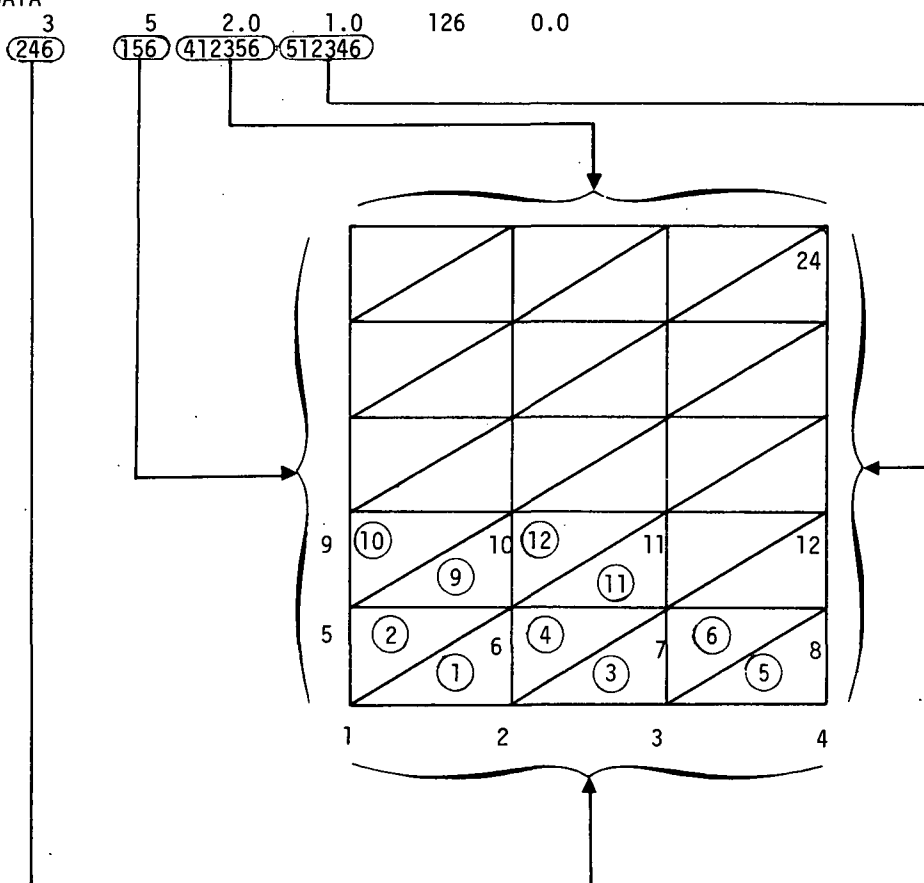
- (1) If IP, IY0, IX0, IYL and IXW are all zero, G4 will be purged.
- (2) A PTRIAL card with PID=101 must be included in the Bulk Data.
- (3) If SPC's are generated the set ID will be 1000NX + NY.

USER GENERATED INPUT

```

ID INPUT, CASE 4
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,/G1,G2,,G4,/C,N,4/C,N,1/C,N,1 $
EQUIV G1,GEØM1/TRUE / G2,GEØM2/TRUE / G4,GEØM4/TRUE $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=RECTANGULAR PLATE MADE FROM CTIA1'S
LABEL=ØPTION 1 WITH CLAMPED SUPPORTS
SPC=3005
LØAD=1
ØUTPUT
DISP=ALL
BEGIN BULK
FORCE 1 1 0 1.0 0.0 0.0 1.0
MAT1 7 1.0 1.0
PTRIA1 101 7 1.0 7 2.0 7 4.0
ENDDATA

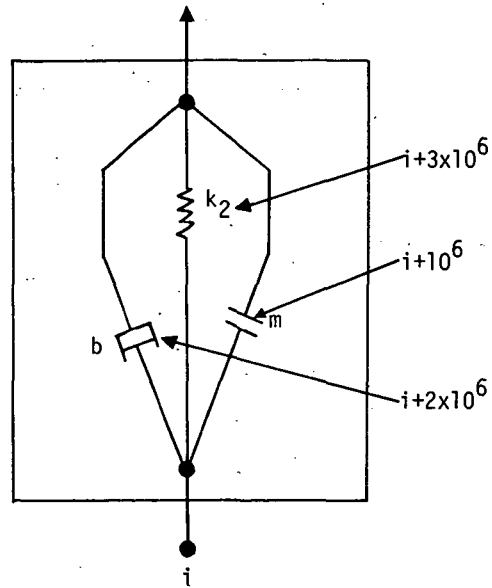
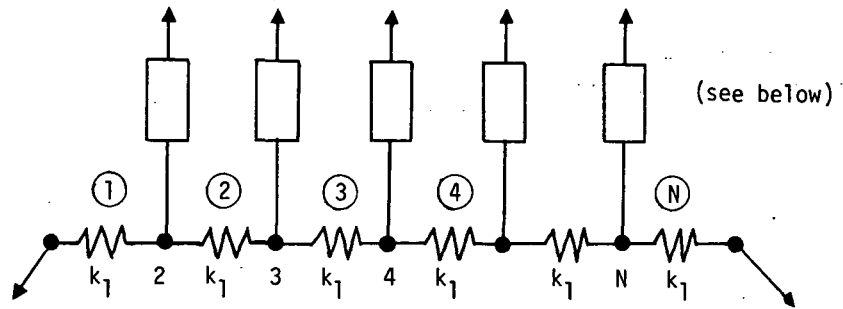
```



NASTRAN DATA DECK

2.6.1.5 N-segment string (a=5, b and c are not used)

INPUT generates CELAS4, CMASS4 and CDAMP4 cards for an N-segment string grounded at both ends.



USER GENERATED INPUT

a. Data Card

1	N	(I8)	No. of segments
2	k_1	(E8.0)	Spring value
3	k_2	(E8.0)	Spring value (if zero, none of these elements are generated)
4	m	(E8.0)	Mass value (if zero, none of these elements are generated)
5	b	(E8.0)	Damper values (if zero, none of these elements are generated)

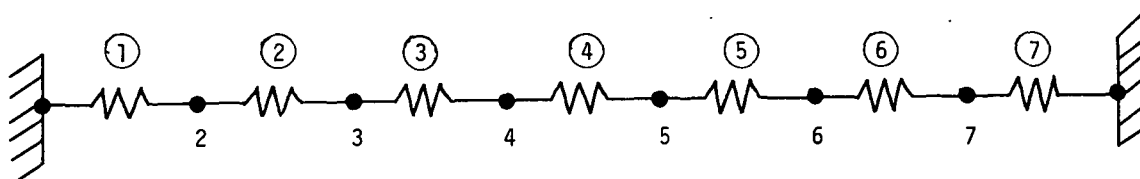
b. Notes

- (1) If any of k_2 , m, or b are zero, those elements will not be generated.

NASTRAN DATA DECK

```

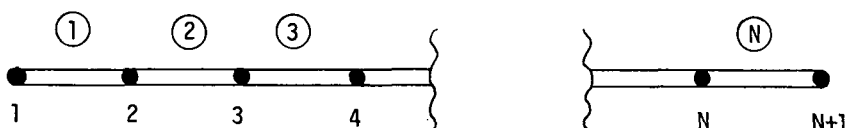
ID INPUT, CASE 5
TIME 30
APP DISP
SOL 1,3
ALTER 1
PARAM //C,N,NOP/V,N,TRUE=-1 $
INPUT, ,,,,/G2,,,/C,N,5 $
EQUIV G2,GEOM2/TRUE $
ENDALTER
CEND
ECH0=BOTH
TITLE=TEST OF UTILITY MODULE INPUT
SUBTITLE=N-SEGMENT STRING
LABEL=STATICS
LOAD=1
OUTPUT
DISP=ALL
BEGIN BULK
LOAD      1      3      1.0      6      1.0
ENDDATA
      7      1.0      0.0      0.0      0.0
    
```



USER GENERATED INPUT

2.6.1.6 N-cell Bar (a=6, b and c are not used)

INPUT generates GRID and CBAR cards for an N-cell bar. OMIT cards will also be created if requested.



a. Data deck

First Card

1	N	(I8)	No. of cells
2	L	(E8.0)	Length of bar
3	IP	(I8)	Permanent constraints
4	IFLG	(I8)	Orientation vector flag
5	IGO	(I8)	GO (used only if IFLG = 2)
6	M	(I8)	No. of right-most grid points to be connected to GP2 via bars with PID = 102
7	IØX	(I8)	ØMIT card count

Second Card (Read only if IFLG = 1)

1	X1	(E8.0)	Orientation vector X1 component
2	X2	(E8.0)	Orientation vector X2 component
3	X3	(E8.0)	Orientation vector X3 component

b. Notes

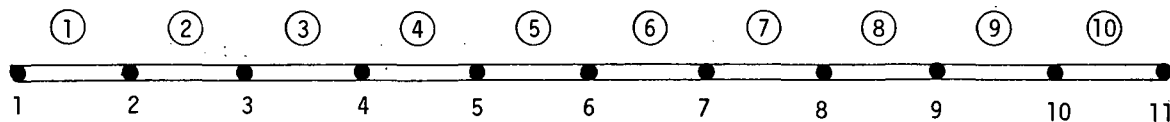
- (1) A PBAR card with PID = 101 is required. If M ≠ 0, a PBAR card with PID = 102 is required.
- (2) IFLG = 2 option is not allowed for this case.
- (3) Do not include G4 in alter packet unless IØX is greater than 0.

NASTRAN DATA DECK

```

ID INPUT, CASE 6
TIME 30
APP DISP
SOL 1,3
ALTER 1
PARAM //C,N,NOP/V,N,TRUE=-1 $
INPUT, ,,,/G1,G2,,,/C,N,6 $
EQUIV G1,GEOM1/TRUE / G2,GEOM2/TRUE $
ENDALTER
CEND
ECH0=BOTH
TITLE=TEST OF UTILITY MODULE INPUT
SUBTITLE=N-CELL BAR
LABEL=STATICS
SPC=1
LOAD=1
OUTPUT
SET 101=11
DISP=101
BEGIN BULK
FORCE      1      11      0      1.0      0.0      1.0      1.0
MAT1       7      1.0      1.0
PBAR      101      7      1.0      2.0      4.0      8.0
SPC        1      1 123456      0.0
PARAM GRDPNT 6
ENDDATA
      10 100.0      0      1      0      0      0
      0.0 0.0      1.0

```



USER GENERATED INPUT

2.6.1.7 Full matrix with optional unit load (a=7, b and c are not used)

INPUT generates N scalar points, all of which are interconnected giving $N(N+1)/2$ elements. On option, SLØAD cards are generated for each CELAS4 scalar point.

a. Data Card

1	N	(I8)	Order of problem	
2	NSLØAD	(I8)	Uniform load flag	$\begin{cases} =0, \text{ will not generate SLØAD cards} \\ \neq 0, \text{ will generate SLØAD cards} \end{cases}$

b. Notes

- (a) GP1 is altered as shown in the example in order to run efficiently.
- (b) If SLØAD cards are generated the load set ID is N.

NASTRAN DATA DECK

```

ID INPUT, CASE 7
TIME 30
APP DISP
SOL 1,3
ALTER 1
PARAM //C,N,NOP/V,N,TRUE=-1 $
INPUT, ,,,,/,G2,G3,,G5/C,N,7 $
EQUIV G2,GEOM2/TRUE / G3,GEOM3/TRUE $
ALTER 4,4
GP1 GEOM1,G5/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/C,N,O/V,N,NOPDT $
ENDALTER
CEND
ECHO=BOTH
TITLE=TEST OF UTILITY MODULE INPUT
SUBTITLE=FULL MATRIX WITH OPTIONAL UNIT LOAD
LABEL=ORDER = 10
LOAD=10
OUTPUT
DISP=ALL
SPCF=ALL
LOAD=ALL
ELFO=ALL
BEGIN BULK
{blank card}
ENDDATA
      10  1

```

NASTRAN DATA DECK

2.7 SUBSTRUCTURE CONTROL DECK

The Substructure Control Deck options provide the user commands needed to control the execution of NASTRAN for automated multi-stage substructure analyses. These commands are input on cards with the same format conventions as are used for the normal NASTRAN Case Control Deck.

Initiation of a substructure analysis is achieved via the Executive Control Deck command (see Section 2.1):

APP DISPLACEMENT,SUBS

This command directs NASTRAN to automatically generate the required DMAP sequence of alters to the specified Rigid Format necessary to perform the operations requested in the Substructure Control Deck. Following the Substructure Control Deck in the NASTRAN input data stream comes the standard Case Control Deck which specifies the loading conditions, omit sets, method of eigenvalue extraction, element sets for plotting, plot control, and output requests, etc.

The Substructure Control Deck commands are summarized in Table 1 where they are listed under one of three categories according to whether they:

1. Specify the phase and mode of execution
2. Specify the substructuring matrix operations
3. Define and control the substructure operating file (SOF)

Several commands have associated with them a set of subcommands used to specify additional control information appropriate to the processing requested by the primary command. These subcommands are defined together with the alphabetically sorted descriptions of their primary commands in Section 2.7.3. Examples utilizing these commands are presented in Section 1.

The sections that follow discuss the interaction between the substructure commands and the standard case control commands, the translation of substructure commands into DMAP ALTER sequences, and the format conventions to be used. The bulk data cards provided for substructure analyses are included with the standard bulk data descriptions in Section 2.3 and they are summarized for convenient reference in Table 2.

NASTRAN DATA DECK

Table 1. Summary of substructure commands.

A. Phase and Mode Control

- SUBSTRUCTURE # - Defines execution phase (1, 2, or 3) (Required)
- OPTIONS - Defines matrix options (K, M, P, or PA)
- RUN - Limits mode of execution (DRY, G0, DRYG0, STEP)
- ENDSUBS # - Terminates Substructure Control Deck (Required)

B. Substructure Operations

- COMBINE - Combines sets of substructures
 - NAME - Names the resulting substructure
 - TOLERANCE* - Limits distance between automatically connected grids
 - CONNECT - Defines sets for manually connected grids and releases
 - OUTPUT - Specifies optional output results
 - COMPONENT - Identifies component substructure for special processing
 - TRANSFORM - Defines transformations for named component substructures
 - SYMTRANSFORM - Specifies symmetry transformation
 - SEARCH - Limits search for automatic connects
- EQUIV - Creates a new equivalent substructure
 - PREFIX* - Prefix to rename equivalenced lower level substructures
- REDUCE - Reduces substructure matrices
 - NAME* - Names the resulting substructure
 - BOUNDARY* - Defines set of retained degrees of freedom
 - OUTPUT* - Specifies optional output requests
 - RSAVE - Save REDUCE decomposition produce
- SOLVE - Initiates substructure solution (statics or normal modes)
- RECOVER - Recovers Phase 2 solution data
 - SAVE - Stores solution data on S0F
 - PRINT - Stores solution and prints data requested
- BRECOVER - Basic substructure data recovery, Phase 3
- PLOT - Initiates substructure undeformed plots

C. S0F Controls

- S0F # - Assigns physical files for storage of the S0F (Required)
- PASSWORD - Protects and insures access to correct file
- S0FOUT or S0FIN - Copies S0F data to or from an external file
 - POSITION - Specifies initial position of input file
 - NAMES - Specifies substructure name used for input
 - ITEMS - Specifies data items to be copied in
- S0FPRINT - Prints selected items from the S0F
- DUMP - Dumps entire S0F to a backup file
- RESTORE - Restores entire S0F from a previous DUMP operation
- CHECK - Checks contents of external file created by S0FOUT
- DELETE - Edits out selected groups of items from the S0F
- EDIT - Edits out selected groups of items from the S0F
- DESTROY - Destroys all data for a named substructure and all the substructures of which it is a component

Mandatory Control Cards

* Required Subcommand

SUBSTRUCTURE CONTROL DECK

Table 2. Substructure Bulk Data Card Summary.

A. Bulk Data Used for Processing Substructure Command REDUCE

- BDYC - Combination of substructure boundary sets of retained degrees of freedom
- BDYS - Boundary set definition
- BDYS1 - Alternate boundary set definition

B. Bulk Data Used for Processing Substructure Command COMBINE

- CØNCT - Specifies grid points and degrees of freedom for manually specified connectivities - will be overridden by RELES data
- CØNCT1 - Alternate specification of connectivities
- RELES - Specifies grid point degrees of freedom to be disconnected - overrides CØNCT and automatic connectivities
- GTRAN - Redefines the output coordinate system grid point displacement sets
- TRANS - Specifies coordinate systems for substructure and grid point transformations

C. Bulk Data Used for Processing Substructure Command SOLVE

- LØADC - Defines loading conditions for static analysis
- MPCS - Specifies multipoint constraints
- SPCS - Specifies single point constraints
- SPCS1 - Alternate specification of single point constraints
- SPCSD - Specifies enforced displacements for single point constraints

NASTRAN DATA DECK

2.7.1 Commands and Their Execution

The sequence of operations is controlled by the order in which NASTRAN encounters the substructure commands. A few special data cards are required in any Substructure Command Deck.

These are:

SUBSTRUCTURE $\left\{ \begin{array}{l} \text{PHASE1} \\ \text{PHASE2} \\ \text{PHASE3} \end{array} \right\}$ - The first card of the Substructure Command Deck and it follows the CEND card of the Executive Control Deck.

$\left. \begin{array}{l} \text{SØF} \\ \text{PASSWØRD} \end{array} \right\}$ - Required to define the substructure operating file to be used for this execution.

ENDSUBS - Signals the end of the Substructure Command Deck.

The first step of any substructuring analysis is to define the basic substructures to be used. These are prepared by executing one Phase 1 run for each substructure. Checkpoints may be taken for each Phase 1 execution to save the files to be used during the Phase 3 data recovery runs. Alternately, the user may resubmit his entire original data deck for a Phase 3 run, thereby avoiding a proliferation of checkpoint tapes. During a Phase 2 execution, a long list of instructions may be specified. This list may be split up and run in several separate smaller steps. No checkpointing is required during a Phase 2 run in that all pertinent substructure data will be retained on the substructure operating file (SØF).

The Case Control Deck submitted following the ENDSUBS card will be used to direct the processing appropriate to the particular Phase being executed. During a Phase 1 run, the Case Control will be used to define the loading conditions, single and multipoint constraints (only one set may be used per basic substructure), omits, and desired plot sets. During a Phase 2 run, the Case Control will be used to specify the loads and constraint data for the SØLVE operation, outputting of results, or any plot requests. Finally, for a Phase 3 execution, the Case Control Deck is used to define the detail output and plot requests for each basic substructure.

Normal substructuring analyses will require many steps to be executed under Phase 2 processing. They may all be submitted for processing at once, or they may be divided into several shorter sequences and executed separately. In the event of an abnormal termination, several steps may have been successfully executed. To recover requires simply removing those completed steps from the Substructure Control Deck and resubmitting the remaining commands. The SØF will act as the checkpoint/restart file independently of the normal NASTRAN checkpointing procedures.

SUBSTRUCTURE CONTROL DECK

If the solution structure is large, a NASTRAN checkpoint would be recommended to save intermediate results during the SOLVE operation. If this is done, however, care must be exercised on restart to insure correct re-entry into the DMAP sequence. This may be accomplished by removing all substructure control commands preceding the SOLVE, modifying the Case Control Deck and Bulk Data Deck to change set identifiers only if any new loads or constraint sets are to be specified and resubmitting the job. If no changes are to be made which would affect the SOLVE operations, a regular restart can be executed without changing the original Case Control and Bulk Data Decks.

The user may wish to add to or modify the DMAP sequence generated automatically from the Substructure Control Deck commands. This user interaction with the DMAP operations is explained in the following section.

2.7.2 Interface with NASTRAN DMAP

Each substructure command card produces a set of DMAP ALTER cards which are automatically inserted into the Rigid Format called for execution on the SOL card of the Execution Control Deck (Section 2.1). These automatically generated alters require no user interfacing unless the user wishes to exercise the following options:

1. The user may insert ALTER cards in the Executive Control Deck. However, they may not overlap any DMAP cards affected by the substructure ALTERs. The DMAP card numbers, modified for each Rigid Format, are given in Chapter 3.
2. The user may suppress the DMAP generated by the substructure deck and run with either ALTER cards or with approach DMAP. To suppress the automatic DMAP, the following forms of the executive control card APP are provided

APP DISP,SUBS,1 (Retains execution of the substructuring preface operations)
or APP DMAP (Standard NASTRAN is executed)

3. For user information and convenience, the substructure ALTER packages may be printed and/or punched on cards. The executive control card, DIAG 23, will produce the printout. DIAG 24 will produce the punched deck. The punched deck may then be altered by the user and resubmitted as described in (2) above. However, the order of the associated substructure command deck must not be changed to insure proper sequencing of the requested operations.

2.7.3 Substructure Control Card Descriptions

The format of the substructure control cards is free-field. In presenting general formats for each card embodying all options, the following conventions are used:

1. Upper-case letters must be punched as shown.
2. Lower-case letters indicate that a substitution must be made.
3. Braces { } indicate that a choice of contents is mandatory.
4. Brackets [] contain an option that may be omitted or included by the user.
5. Underlined options or values are the default values.
6. Physical card consists of information punched in columns 1 thru 72 of a card. All

Substructure Control Cards are limited to a single physical card.

The Case Control Deck, which follows the ENDSUBS card of the Substructure Control Deck is described in Section 2.3.

SUBSTRUCTURE CONTROL DECK

Substructure Command BRECOVER - Basic Substructure Data Recovery

Purpose: This operation is performed in Phase 3 to recover detailed output data for a basic substructure used in Phase 1.

Request Format:

BRECOVER name

Subcommands: None

Definitions:

name - Name of structure defined in Phase 1 or structure equivalenced to the Phase 1 structure.

- Notes:
1. Use of the RECOVER command in Phase 3 has the same effect as BRECOVER. That is, RECOVER is an alias for BRECOVER in Phase 3.
 2. Phase 3 may be a RESTART of the original Phase 1 run or it may be executed from the original input data.

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Substructure Command CHECK - Check Contents of External File

Purpose: To list all substructure items on an external file which was generated with SØFØUT.

Request Format:

CHECK filename { DISK }
 { TAPE }

Subcommands: None

Definitions:

filename - Name of the external file. One of the following: INPT, INP1,..., INP9.

DISK - File resides on a direct access device.

TAPE - File resides on tape.

Notes: 1. The substructure name, item name, and the date and time the item was written are listed for each item on the file.

SUBSTRUCTURE CONTROL DECK

Substructure Command CØMBINE - Combine Sets of Substructures

Purpose: This operation will perform the operations to combine the matrices and loads up to seven substructures into matrices and loads representing a new pseudostructure. Each component structure may be translated, rotated, and reflected before it is connected. The user may manually select the points to be connected or direct the program to connect them automatically.

Request Format:

CØMBINE ({ $\frac{\text{AUTØ}}{\text{MAN}}$ }, { $\frac{X}{Y}{Z}$ }) name1, name2, etc.

Subcommands:

NAME = new name (required)
 TØLERANCE = ϵ (required)
 CØNNECT = n
 ØUTPUT = m_1, m_2, \dots

Each individual component substructure may have the following added commands:

CØMPØNENT	= name	} repeat for each component
TRANSFØRM	= m	
SYMTRANSFØRM	= { $\frac{X^-}{Y}{Z}{XY}{XZ}{YZ}{XYZ}$ }	
SEARCH	= namej, namek, etc.	

Definitions:

- AUTØ/MAN - Defines method of connecting points. If AUTØ is chosen, the physical location of grid points is used to determine connections. If MAN, all connections are defined on CØNCT or CØNCT1 bulk data.
- X, Y, Z - Are used on CØMBINE card for searching geometry data for AUTØ connections. Denotes preferred search direction for processing efficiency.
- name1, name2, etc. - Unique names of substructures to be combined. Limits are from one to seven component structures.
- new name - Defines name of combination structure (required).
- ϵ - Defines limit of distance between points which will be automatically connected (real > 0).
- n - Defines set number of manual connections and releases specified on bulk data cards, CØNCT, CØNCT1, and RELES.
- name - On CØMPØNENT card defines which substructure (name1, etc.) to which the following data is applied.

NASTRAN DATA DECK

- m - Set identification number of TRANS and GTRAN bulk data cards which define the orientation of the substructure and/or selected grid points relative to new basic coordinates.
- X, Y,...XY,...XYZ - Defines axis (or set of axes) normal to the plane(s) of symmetry in the new basic coordinate system. The displacement and location coordinates in these directions will be reversed in sign.
- namej, namek, etc. - Limits the automatic connection process such that only connections between component "name" and these structures are produced.
- m₁, m₂, etc. - Optional output requests (see Note 4).

- Notes:
1. The automatic connections are produced by first sorting the grid point coordinates in the specified coordinate direction and then searching within limited groups of coordinates. If the boundary of a substructure to be connected is aligned primarily along one of the coordinate axes, this axis should be used as the preferred search direction. If the boundary is parallel with, say, the yz plane and all boundary coordinates have a constant x value, then the search should be specified along either the y or the z axis.
 2. The transformation (TRANS) data defines the orientation of the component substructure (old basic) in terms of the new basic coordinate system. All grid points originally defined in the old basic system will be transformed to the new basic system. Points defined in local coordinate systems will not be transformed unless otherwise specified on a GTRAN card, and their directions will rotate with the substructure.
 3. The SYMTRANFORM (or SYMT) request is primarily used to produce symmetric reflections of a structure. This is usually preceded by an EQUIV command to produce a new, unique substructure name. Note that the results for the new reflected substructure may reference a left-handed coordinate system wherever local coordinate systems are retained during the transformation. However, those coordinates which are originally in the old basic or are newly specified via a GTRAN card are automatically transformed to a right-handed coordinate system of the combined structure during the combination process.
 4. The following output requests are available for the COMBINE operation:

<u>CODE</u>	<u>OUTPUT</u>
2*	SOF table of contents
3	CØNCT1 bulk data summary
4	CØNCT bulk data summary
6	GTRAN bulk data summary
7*	TRANS bulk data summary
9	RELES bulk data summary
11	Summary of automatically generated connections (in terms of internal point numbers)
12	Complete connectivity map of final combined pseudostructure defining each internal point in terms of the grid point ID and component substructure it represents
13	The EQSS item
14	The BGSS item
15	The CSTM item
16	The PLTS item
17	The LØDS item

} Output printed is formatted SOF data
for the newly created pseudostructure
(See Section 1.14 for definitions)

*recommended output items

SUBSTRUCTURE CONTROL DECK

Examples:

1. CØMBINE PANEL SPAR
TØLE = .0001
NAME = SECTA
2. CØMBINE (AUTØ,Z) TANK1, TANK2, BULKHD
NAME = TANKS
TØLE = .01
CØMPØNENT TANK1
TRAN = 4
SEARCH = BULKHD
CØMPØNENT TANK2
SEARCH = BULKHD
3. CØMBINE (MAN) LWING, RWING
TØLE = 1.0
NAME = WING
CØMPØNENT LWING
SYMT = Y

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Substructure Command DELETE

Purpose: To delete individual substructure items from the SØF.

Request Format:

DELETE name, item1, item2, item3, item4, item5

Subcommands: None

Definitions:

name - Substructure name

item1, item2, ... - Item names (HØRG, KMTR, LØDS, SØLN, etc.)

- Notes:
1. DELETE may be used to remove from one to five items of any single substructure.
 2. For primary substructures, items of related secondary substructures are removed only if the later point to the same data (KMTX, MMTX, etc.).
 3. For secondary and image substructures, no action is taken on items of related substructures, i.e., items of equivalenced substructures or higher or lower level substructures.
 4. See the EDIT and DESTROY commands for other means of removing substructure data.

SUBSTRUCTURE CONTROL DECK

Substructure Command DESTROY - Removes All Data Referencing a Component Substructure

Purpose: To remove data for a substructure and all substructures of which it is a component from the SØF. In addition to the substructure being DESTROY'ed ("name"), data for substructures which satisfy one or more of the following conditions are also removed from the SØF:

1. All substructures of which "name" is a component
2. All secondary (or equivalenced) substructures for which "name" is the primary substructure
3. All image substructures which are components of a substructure that is destroyed

Request Format:

DESTROY name

Subcommands: None

Definition:

name - Name of substructure

Notes: 1. No action is taken if "name" is an image substructure.

2. See related commands EDIT and DELETE for additional means of removing substructure data.

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Substructure Command DUMP

Purpose: To copy the entire SØF to an external file.

Request Format:

DUMP filename { DISK }
 { TAPE }

Subcommands: None

Definitions:

Filename - Name of the external file. Any one of the following: INPT, INP1,..., INP9.

DISK - File resides on a direct access device.

TAPE - File resides on tape.

- Notes:
1. DUMP may be used to create a backup copy of the SØF.
 2. All system information on the SØF is saved.
 3. The RESTØRE command will reload a DUMPed SØF.

SUBSTRUCTURE CONTROL DECK

Substructure Command EDIT - Selectively Removes Data from SØF File

Purpose: To permanently remove selected substructure data from the SØF.

Request Format:

EDIT (opt) name

Subcommands: None

Definitions:

name - Name of substructure.

opt - Integer value reflecting combinations of requests. The sum of the following integers defines the combination of data items to be removed from the SØF.

<u>ØPT</u>	<u>Items Removed</u>
1	Stiffness Matrix (KMTX)
2	Mass Matrix
4	Load Data
8	Solution Data
16	Transformation Matrices defining next level (HØRG)
32	All items for the substructure

Notes: 1. The user is cautioned on the removal of the HØRG matrix data. These matrices are required for the recovery of the solution results.

2. If the EDIT feature is to be employed, the user should consider also using SØFØUT to insure the existence of backup data in the event of an error.

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Substructure Command EQUIV - Create a New Equivalent Substructure

Purpose: To assign an alias to an existing substructure and thereby create a new equivalent substructure. The new secondary substructure may be referenced independently of the original primary substructure in subsequent substructure commands. However, the data actually used in substructuring operations is that of the primary substructure.

Request Format:

EQUIV name1, name2

Subcommands:

PREFIX = p

Definitions:

- p - Single BCD character.
- name1 - Existing primary substructure name.
- name2 - New equivalent substructure name.

- Notes:
1. A substructure created by this command is referred to as a secondary substructure.
 2. All substructures which were used to produce the primary substructure will produce equivalent image substructures. The new image substructure names will have the prefix p.
 3. A DESTROY operation on the primary substructure data will also destroy the secondary substructure data and all image substructures.
 4. An EDIT or DELETE operation on the primary substructure will not remove data of the secondary substructure and vice versa.

SUBSTRUCTURE CONTROL DECK

Substructure Mode Control OPTIONS - Defines Matrix Types

Purpose: This allows the user to selectively control the type of matrices being processed.

Request Format:

OPTION m1,m2,m3

Subcommands: None

Definition:

m1,m2,m3 - Any combination of the characters K, M, and either P or PA, where:

K = Stiffness Matrices
M = Mass Matrices
P = Load Matrices
PA = Appended Load Vectors

Notes: 1. The default depends on the NASTRAN rigid format:

<u>Rigid Format</u>	<u>Default</u>
1 - Statics	K,P
2 - Inertia Relief	K,M,P
3 - Normal Modes	K,M

- In a Phase 1 execution, Rigid Formats 1 and 3 will provide only two of the matrices, as shown above. In Rigid Format 1, the mass matrix is not generated. In Rigid Format 3, the loads matrix is not generated. An error condition will result unless the user adds the required DMAP alters to provide the requested data.
- Stiffness, mass, or load matrices must exist if the corresponding K, M, P, or PA option is requested in the subsequent Phase 2 run.
- Matrices or loads may be modified by rerunning the substructure sequence for only the desired type. However, the old data must be deleted first with the EDIT or DELETE command. See Section 1.11 for the actual item names.
- The append load option, PA, is used when additional load sets are required for solution, and it is not desired to regenerate existing loads. To generate these new load vectors, re-execute all required Phase 1 runs with the new load sets and OPTION = PA. Then, repeat the Phase 2 operations with OPTION = PA. At each step, the new vectors are appended to the existing loads so that all load vectors will be available in the SOLVE stage.
- Each OPTION command overrides the preceding command to control subsequent steps of the substructure process.

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Substructure Operating File Declaration PASSWØRD

Purpose: This declaration is required in the substructure command deck. The password is written on the SØF file and is used to protect the file and insure that the correct file is assigned for the current run.

Request Format:

PASSWØRD password

Subcommands: None

Definition:

password - BCD password for the SØF (8 characters maximum). See the SØF file declaration card description.

SUBSTRUCTURE CONTROL DECK

Substructure Command PLØT - Substructure Plot Command

Purpose: This operation is used to plot the undeformed shape of a substructure which may be composed of several component substructures. This command initiates the execution of a plot at any stage of the substructure process. The actual plot commands; origin data, etc., must be included in the normal case control data.

Request Format:

PLØT name

Subcommands: None

Definitions:

name - Name of component substructure to be plotted.

- Notes:
1. The set of elements to be plotted will consist of all the elements and grid points saved in Phase 1 for each basic substructure comprising the substructures named in the PLØT command. (Only one plot set from each basic substructure is saved in Phase 1.)
 2. The structure plotter output request packet, while part of the standard Case Control Deck, are treated separately in Sections 4.2 and 4.3, respectively.

NASTRAN DATA DECK

Substructure Command RECOVER - Phase 2 Solution Data Recovery

Purpose: This operation recovers displacements and boundary forces on specified substructures in the Phase 2 execution. The results are saved on the SØF file and they may be printed upon user request. This command should be input after the SØLVE command to store the solution results on the SØF file.

Request Format:

RECOVER s-name

Subcommands:

SAVE = name

PRINT = name

Definitions:

s-name - Name of the substructure named in a prior SØLVE command from which the solution results are to be recovered.

name - Name of the component structure for which results are to be recovered. May be the same as "s-name".

- Notes:
1. SAVE will save the solution for substructure "name" on the SØF. PRINT will save and print the solution.
 2. The actual printout is controlled by the output requests specified in the Case Control Deck (DISP, SPCF, and ØLØAD). If there are no output requests in Case Control, PRINT is equivalent to SAVE and nothing will be printed.
 3. For efficiency, the user should order multiple SAVE and/or PRINT commands so as to trace one branch at a time starting from his solution structure.
 4. Reaction forces are computed for a substructure only if (1) the substructure is named on a PRINT subcommand and, (2) an output request for SPCFØRCE exists in the Case Control.

SUBSTRUCTURE CONTROL DECK

Substructure Command REDUCE - Phase 2 Reduction to Retained Degrees of Freedom

Purpose: This operation performs a Guyan matrix reduction process for a specified component substructure, otherwise known as matrix condensation. It produces the same result as obtained by the specification of NASTRAN OMIT or ASET data. The purpose is to reduce the size of the matrices. In static analysis only points on the boundary need be retained. In dynamics, the boundary points and selected interior points are retained.

Request Format:

REDUCE name

Subcommands:

NAME - new name

BØUNDARY - n

ØUTPUT - m₁, m₂,...

RSAVE

Definitions:

name - Name of substructure to be reduced.

new name - Name of resulting substructure.

n - Set identification number of BDYC bulk data cards which define sets of retained degrees of freedom for the resulting reduced substructure matrices.

m₁, m₂, etc. - Optional output requests (see Note 3).

- Notes:
1. All references to the grid points and components not defined in the "boundary set" will be reduced out of the new substructure. Any subsequent reference to these omitted degrees of freedom in CØMBINE, REDUCE, or SØLVE operations generated an error condition.
 2. The same transformations will be applied to the reduced mass matrix for the new substructure. See the NASTRAN Theoretical Manual for a discussion of this effect.
 3. The following output requests are available for the REDUCE operation (* marks recommended output options):

<u>CODE</u>	<u>OUTPUT</u>
1*	Current problem summary
2	Boundary set summary
3	Summary of grid point ID numbers in each boundary set
4	The EQSS item for the structure being reduced
5*	The EQSS item
6*	The BGSS item
7	The CSTM item
8	The PLTS item
9*	The LØDS item

} These requests write formatted SØF items for the new reduced pseudostructure

4. If the RSAVE card is included, the decomposition product of the interior point stiffness matrix (LMTX item) is saved on the SØF file. This matrix will be used in the data recovery for the omitted points. If it is not saved it will be regenerated when needed.

NASTRAN DATA DECK

Substructure Command RESTORE

Purpose: To reload the SØF from an external file created with the DUMP command.

Request Format:

RESTORE filename { DISK }
 { TAPE }

Subcommands: None

Definitions:

Filename - Name of the external file. Any one of the following: INPT, INP1,..., INP9.

DISK - File resides on a direct access device.

TAPE - File resides on tape.

- Notes:
1. The external file must have been created with the DUMP command.
 2. The SØF must be declared as 'NEW' on the SØF command.
 3. RESTORE must be the very first substructure command following the SØF and PASSWORD declarations.

SUBSTRUCTURE CONTROL DECK

Substructure Mode Control RUN - Specifies Run Options

Purpose: This command is used to limit the substructure execution for the purpose of checking the validity of the input data. It allows for the processing of input data separately from the actual execution of the matrix operations.

Request Format:

RUN { DRY
 GØ
 DRYGØ
 STEP }

Subcommands: None

Definitions:

- DRY - Limits the execution to table and transformation matrix generation. Matrix operations are skipped.
- GØ - Limits the execution to matrix generation only. This mode must have been preceded by a successful RUN=DRY execution.
- DRYGØ - Will cause execution of a complete dry run for the entire job, followed by a RUN=GØ execution if no fatal errors were detected.
- STEP - Will cause the execution of both DRY and GØ operations one step at a time.

- Notes: 1. The DRY, GØ and STEP options may be changed at any step in the input substructure command sequence. If the DRYGØ option is used, the RUN card must appear only once at the beginning.
2. If a fatal error occurs during the first pass of the DRYGØ option, the program exits at the completion of all DRY operations.

NASTRAN DATA DECK

Substructure Operation File Declaration SØF - Assigns Physical Files for Storage of the SØF

Purpose: This declaration defines the names and sizes of the physical NASTRAN files the user assigns for storage of the SØF file. At least one of these declarations must be present in each substructure command deck. As many SØF declarations are required in the substructure command deck on each run as there are physical files assigned for the storage of the SØF file.

Request Format:

SØF(no.) = filename, filesize, $\begin{Bmatrix} \text{OLD} \\ \text{NEW} \end{Bmatrix}$

Subcommands:

PASSWØRD = password

Definitions:

- no. - Integer index of SØF file (1, 2, etc.) in ascending order of files required for storage of the SØF. The maximum index is 10.
- filename - User name for an SØF physical file.
- filesize - Size of allocated file space in kilowords, default = 100.
- ØLD - SØF data is assumed to already exist on the file.
- NEW - The SØF is new. In this case, the SØF will be initialized.
- password - BCD password for the SØF (8 characters maximum) used to protect the file and insure that the correct file is assigned for the current run (see the PASSWØRD card description).

- Notes:
1. If more space is required for storage of the SØF file, additional physical files may be declared. Alternately, the file size parameter on a previously declared file may be increased, but only on the last physical file if more than one is used (on IBM the size of an existing file may not be increased).
 2. Once an SØF declaration is made, the index of the SØF file must always be associated with the same file name. File names may not be changed from run to run.
 3. The file names of each physical SØF file must be unique.
 4. The declared size of the SØF may be reduced by the amount of contiguous free-space at the end of the logical SØF file. This may be accomplished by removing the physical file declaration for those unused files which have the highest sequence numbers. And, the size of the physical file with the highest sequence number of those remaining may be reduced. An attempt to eliminate a portion of the SØF which contains valid data will result in a fatal error.
 5. If the NEW parameter is present on any one of the SØF declarations, the entire logical SØF is considered new. Therefore, if an additional physical file is added to an existing SØF, the NEW parameter should not be included on any declarations.
 6. The following conventions should be used for the file name declarations on each of the three NASTRAN computers:

CDC 6400/6600

Any 4-character alphanumeric name is acceptable. No special characters or blanks may be used. The file name used on the SØF declaration must correspond to ones used on the system REQUEST or ATTACH card. Note that after a NASTRAN execution, the SØF files should be catalogued or extended.

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Examples:

1. Create a new SØF file with a filename of SØF1 and catalogue it.

```
REQUEST(SØF1,*PF)
NASTRAN.
CATALØG(SØF1,username)
789
```

```
NASTRAN data cards including the SØF declaration --
SØF(1)=SØF1,1000,NEW
```

6789

2. Use of an existing SØF file with a filename of ABCD.

```
ATTACH(ABCD,username)
NASTRAN.
EXTEND(ABCD)
789
```

```
NASTRAN data cards including the SØF declaration --
SØF(1)=ABCD,1000
```

6789

UNIVAC 1108

The filename used on the SØF declaration must specify one of the NASTRAN user files INPT, INP1,..., INP9.

Examples:

1. Create a new SØF file named INPT.

```
@ASG,U INPT.F///1000
@HDG,N
@XQT *NASTRAN.LINK1
```

```
NASTRAN data cards including the SØF declaration --
SØF(1)=INPT,400,NEW
```

```
@ADD,P *NASTRAN.CØNTRL
@FIN
```

2. Use of an existing SØF file with a filename of INP7.

```
@ASG,AX INP7.
@HDG,N
@XQT, *NASTRAN.LINK1
```

```
NASTRAN data cards including the SØF declaration --
SØF(1)=INP7,250
```

```
@ADD,P *NASTRAN.CØNTRL
@FIN
```

NASTRAN DATA DECK

IBM 360/370

The file name used on the SØF declaration must specify one of the following ten file names: SØFØ, SØF1, SØF2, ... , SØF9.

The JCL (Job Control Language) DD (data definition) card, not the NASTRAN SØF declaration, is used by the IBM operating system to allocate units to NASTRAN for use as SØF datasets. There must be one DD card corresponding to each NASTRAN SØF declaration; the DD card DDNAME parameter must exactly correspond to the four-character file name of the SØF declaration of the Substructure Control Deck. The physical unit specified on the DD card must be a direct access device. On IBM, the SØF declaration file size parameter is ignored and the actual size of the SØF file is obtained from the SPACE parameter of the DD card.

Examples:

1. Create a new SØF dataset with a filename SØF1 and 1000 blocks.

```
//NSGØ EXEC NASTRAN
//NS.SØF1, DD DSN=username,UNIT=2314,VØL=SØF1,DISP=(NEW,KEEP)
// SPACE=(7200,(1000)),DCB=BLKSIZE=7200
//NS.SYSIN DD *
```

```
.....
```

NASTRAN data cards including the SØF declaration --

```
SØF(1)=SØF1,,NEW
```

```
.....
```

```
/*
```

Note: The dataset disposition must be DISP=(NEW,KEEP) when the SØF dataset is created. However, an existing SØF dataset may be re-initialized by coding NEW on the SØF declaration in the NASTRAN data deck. In this case, the disposition on the DD card should be coded DISP=ØLD.

2. Use of an existing SØF dataset with a filename of SØF7.

```
//NSGØ EXEC NASTRAN
//NS.SØF7 DD DSN=username,UNIT=3330,VØL=SØF7,DISP=ØLD,
//NS.SYSIN DD *
```

```
.....
```

NASTRAN data cards including the SØF declaration --

```
SØF(1)=SØF7
```

```
.....
```

```
/*
```

NASTRAN DATA DECK

Substructure Command SØFIN

Purpose: To copy substructure items from an external file to the SØF.

Request Format:

SØFIN { (EXTERNAL
INTERNAL) } filename { ,DISK
TAPE }

Subcommands:

POSITION = { REWIND
NØREWIND }

NAMES = { substructure name
WHØLESØF }

ITEMS = { ALL
MATRICES
PHASE3
TABLES
item name }

Definitions:

EXTERNAL - File was written on a different computer type.

INTERNAL - File was written with GINØ on the same computer type.

Filename - Name of the external file. If the file is in INTERNAL format, filename must specify INPT, INP1,...,INP9. If the file is in EXTERNAL format, filename must specify a FØTRAN unit by using the form FØRT1, FØRT2,...,FØRT32.

DISK - File is located on a direct access device.

TAPE - File is located on a tape.

PØSITION - Specifies initial file position.

REWIND: file is rewound

NØREWIND: input begins at the current position

NAMES - Identifies a substructure for which data will be read. If NAMES=WHØLESØF is coded, and no other NAMES subcommands appear for the current SØFIN command, all substructure items found on the external file from the point specified by the PØSITION subcommand to the end-of-file are copied to the SØF.

ITEMS - Identifies the data items which are to be copied to the SØF for each substructure specified by the NAMES subcommands.

ALL: all items

MATRICES: all matrix items

PHASE3: the UVEC, QVEC, and SØLN items

TABLES: all table items

item name: name of an individual item

Notes: 1. Filename is required. The other SØFIN operands are optional.

2. All subcommands are optional.

SUBSTRUCTURE CONTROL DECK

3. The NAMES subcommand may appear up to five times for each SØFIN command.
4. If a substructure name of an item which is to be copied to the SØF does not exist on the SØF, it is added to the SØF. MDI(Master Data Index) pointers for higher level, combined structures and lower level are restored.
5. The PØSITION subcommand must be specified as REWIND for the EXTERNAL form of this command. All items on the external file are then read in. (User specifications for other subcommands are ignored.)
6. SØFØUT is the companion substructure command.
7. On IBM computers and for the EXTERNAL form of this command, the following DD card should be used:

```
//NS.FTxxF001 DD DSN=username,UNIT=2400-1,DISP=(,KEEP),  
// LABEL=(,NL),DCB=(RECFM=FB,LRECL=132,BLKSIZE=3960,  
// TRTCH=T,DEN=2)
```

NASTRAN DATA DECK

Substructure Command SØFØUT

Purpose: To copy substructure items from the SØF to an external file.

Request Format:

SØFØUT { (EXTERNAL) } filename { ,DISK }
 { (INTERNAL) }

Subcommands:

PØSITIØN = { REWIND }
 { NØREWIND }
 { EØF }

NAMES = { substructure name }
 { WHØLESØF }

ITEMS = { ALL }
 { MATRICES }
 { PHASE3 }
 { TABLES }
 { item name }

Definitions:

EXTERNAL - File will be written so that it may be read on a different computer type.

INTERNAL - File will be written with GINØ.

Filename - Name of the external file. If the file is in INTERNAL format, filename must specify INPT, INP1,...,INP9. If the file is in EXTERNAL format, filename must specify a FØRTTRAN unit by using the form FØRT1, FØRT2,...,FØRT32.

DISK - File is located on a direct access device.

TAPE - File is located on a tape.

PØSITIØN - Specifies initial file position.

REWIND: file is rewind

NØREWIND: output begins at the current position

EØF: file is positioned to the point immediately preceding the end-of-file mark.

NAMES - Identifies a substructure for which data will be written. If NAMES=WHØLESØF is coded and no other NAMES subcommands appear for the current SØFØUT command, all substructure items found on the SØF are copied to the external file.

ITEMS - Identifies the data items which are to be copied to the external file for each substructure specified by the NAMES subcommands.

ALL: all items

MATRICES: all matrix items

PHASE3: the UVEC, QVEC, and SØLN items

TABLES: all table items

item names: name of an individual item

Notes: 1. Filename is required. The other SØFØUT operands are optional.

SUBSTRUCTURE CONTROL DECK

2. All subcommands are optional.
3. The NAMES subcommand may appear up to five times for each SØFØUT command.
4. PLTS items of pseudostructures reference the PLTS items of the component basic substructures. Therefore, in order to save all data necessary to plot a pseudostructure, the PLTS items of its component basic substructures must be saved as well as the PLTS item of the pseudostructure.
5. For the external form of this command, PØSITIØN=NØREWIND has the effect of positioning the file to the end-of-file.
6. PØSITIØN=REWIND should be coded for the first write to a new file.
7. SØFIN is the companion substructure command.
8. On IBM computers and for the EXTERNAL form of this command, the following DD card should be used:

```
//NS.FTxxFOO1 DD DSN=username,UNIT=2400-1,DISP=(,KEEP),  
// LABEL=(,NL),DCB=(RECFM=FB,LRECL=132,BLKSIZE=3960,  
// TRTCH=T,DEN=2)
```


NASTRAN DATA DECK

Substructure Command SØFPRINT

Purpose: To print selected contents of the SØF file for data checking purposes.

Request Format:

SØFPRINT(opt) name, item1, item2, etc.

Subcommands: None

Definitions:

opt - integer, control option, default = 0.

opt = 1: prints data items only

opt = 0: prints table of contents

opt = -1: prints both

name - Name of substructure for which data is to be printed.

item1, item2 - SØF item name, used only when opt ≠ 0, limit = 5 (See Table 2.7-1).

Notes: 1. If only the table of contents is desired (opt = 0), this command may be coded:

SØFPRINT TØC

On the page heading for the table of contents, the labels are defined as follows:

IS - Image substructure flag. 0 - not an image substructure

1 - image substructure

SS - Secondary substructure number (successor)

PS - Primary substructure number (predecessor)

LL - Lower level substructure number

CS - Combined substructure number

HL - Higher level substructure number

SUBSTRUCTURE CONTROL DECK

Substructure Command SØLVE - Substructure Solution

Purpose: This command initiates the substructure solution phase. The tables and matrices for the pseudostructure are converted to their equivalent NASTRAN data blocks. The substructure grid points referenced on bulk data cards SPCS, MPC, etc., are converted to pseudostructure scalar point identification numbers. The NASTRAN execution then proceeds as though a normal structure were being processed.

Request Format:

SØLVE name

Subcommands: None (Case Control and Bulk Data decks control the operations.)

Definition:

name - Name of pseudostructure to be analyzed with NASTRAN.

Notes: 1. Before requesting a SØLVE, the user should check to be sure that all necessary matrices are available on the SØF file. For instance, loads and stiffness matrices are necessary in statics analysis. Mass and stiffness matrices are necessary in eigenvalue analysis, etc.

NASTRAN DATA DECK

Substructure Command SUBSTRUCTURE - Initiates the Substructure Control Data Deck

Purpose: This command initiates the processing for automated substructuring and defines the phase of the analysis. It must be the first card in the Substructure Control Deck.

Request Format:

SUBSTRUCTURE { PHASE1 }
 { PHASE2 }
 { PHASE3 }

Subcommands:

NAME = name (required for PHASE1 only)

SAVEPLOT = n (used only in PHASE1)

RECOVER = name (used only in PHASE3)

BRECOVER = name (used only in PHASE3)

Definitions:

- name - The name assigned to the basic substructure which is being created in PHASE1 or for which results are to be computed in PHASE3.
- n - The plot set identification used to define the one set of elements and grid points to be saved in PHASE1 for subsequent plotting in PHASE2.

- Notes:
1. The mode command RUN=STEP is assumed initially if the explicit command is not given immediately following the SUBSTRUCTURE command.
 2. No further substructure commands are required for PHASE1 and PHASE3.
 3. Additional substructure commands are required for PHASE2.
 4. For PHASE3 operations, RECOVER and BRECOVER are equivalent and one of them must be present.

RIGID FORMATS

3.1 GENERAL DESCRIPTION OF RIGID FORMATS

The most general way of using NASTRAN is with a user written Direct Matrix Abstraction Program (DMAP). This procedure permits the user to execute a series of matrix operations of his choice along with any utility modules or executive operations that he may need. The user may even choose to write a module of his own. The rules governing all of these operations are described in Section 5.

In order to relieve the user from the necessity of constructing a DMAP sequence for each of his problems, a number of such sequences have been included in NASTRAN as rigid formats. A rigid format consists of two parts. The first part is a DMAP sequence that is stored in NASTRAN and available to the user by specifying the number of the rigid format on the SØL card in the Executive Control Deck. The second part of a rigid format is a set of restart tables that automatically modify the series of DMAP operations to account for any changes that are made in any part of the Data Deck when making a restart, after having previously run all, or a part of the problem. Without such tables, the user would have to carefully modify his DMAP sequence to account for the conditions surrounding each restart. The chances for error in making these modifications for restart are very great. The restart tables not only relieve the user of the burden of modifying his DMAP sequence, but also assures him of a correct and efficient program execution.

In addition to the DMAP sequence provided with each rigid format, a number of options are available, which are subsets of each complete DMAP sequence. Subsets are selected by specifying the subset numbers (zero for the complete DMAP sequence) along with the rigid format number on the SØL card in the Executive Control Deck. See Section 2.2.1 for list of available subsets.

If the user wishes to modify the DMAP sequence of a rigid format in some manner not provided for in the available subsets, he can use the ALTER feature described in Section 2. Typical uses are to schedule an EXIT prior to completion, in order to check intermediate output, schedule the printing of a table or matrix for diagnostic purposes, and to delete, or add a functional module to the DMAP sequence. Any DMAP instructions that are added to a rigid format are automatically executed when a restart is performed. The user should be familiar with the rules for DMAP programming, as described in Section 5, prior to making alterations to a rigid format.

RIGID FORMATS

The following rigid formats for structural analysis are currently included in NASTRAN:

1. Static Analysis
2. Static Analysis with Inertia Relief
3. Normal Mode Analysis
4. Static Analysis with Differential Stiffness
5. Buckling Analysis
6. Piecewise Linear Analysis
7. Direct Complex Eigenvalue Analysis
8. Direct Frequency and Random Response
9. Direct Transient Response
10. Modal Complex Eigenvalue Analysis
11. Modal Frequency and Random Response
12. Modal Transient Response
13. Normal Modes Analysis with Differential Stiffness
14. Static Analysis with Cyclic Symmetry
15. Normal Modes Analysis with Cyclic Symmetry

The following rigid formats for heat transfer analysis are included in NASTRAN:

1. Linear Static Heat Transfer Analysis
3. Nonlinear Static Heat Transfer Analysis
9. Transient Heat Transfer Analysis

The following rigid format for subsonic aeroelastic analysis is included in NASTRAN:

10. Modal Flutter Analysis

3.1.1 Input File Processor

The Input File Processor operates in the Preface prior to the execution of the DMAP operations in the rigid format. A complete description of the operations in the Preface is given in the Programmer's Manual. The main interest here is to indicate the source of data blocks that are created in the Preface and hence appear only as inputs in the DMAP sequences of the rigid formats. None of the data blocks created by the Input File Processor are checkpointed, as they are always regenerated on restart. The Input File Processor is divided into five parts. The first part (IFP1) processes the Case Control Deck, the second part (IFP) processes the Bulk Data

GENERAL DESCRIPTION OF RIGID FORMATS

Deck, the third part (IFP3) performs additional processing of the bulk data cards associated with the conical shell element, and the fourth part (IFP4) performs additional processing of the bulk data cards associated with the fluid element. The fifth section (IFP5) processes data related to acoustic cavity analysis.

IFP1 processes the Case Control Deck and creates the Case Control Data Block (CASECC), the Plot Control Data Block (PCDB), and the XY-Plot Control Data Block (XYCDB). IFP1 also examines all of the cards, except those associated with plotting, for errors in format or use. If errors are detected, they are classed as either fatal or warning, and suitable error messages are provided. Reference to Section 2.3 will assist the user in correcting errors in the Case Control Deck. If the error is fatal, the Executive System will not allow the execution to continue beyond the completion of the Preface.

The Bulk Data Deck is sorted in the Preface, if necessary, before the execution of the second part of the Input File Processor. IFP checks all of the bulk data cards for errors according to the rules given for each card in Section 2.4. If errors are detected, suitable messages are provided to the user. If the error is classed as fatal, the Executive System will not allow the execution to continue beyond the completion of the Preface. IFP creates the data blocks that are input to the various parts of the Geometry Processor (GEØM1, GEØM2, GEØM3 and GEØM4), the Element Properties Table (EPT), the Material Properties Table (MPT), the Element Deformation Table (EDT), and the Direct Input Table (DIT).

The third part of the Input File Processor (IFP3) converts the information on the special conical shell cards (CCØNEAX, CTRAPAX, CTRIAAX, FØRCEAX, MØMAX, MPCAX, ØMITAX, PCØNEAX, PØINTAX, PRESAX, PTRAPAX, PTRIAAX, RINGAX, SECTAX, SPCAX, SUPAX, AND TEMPAX) to reflect the number of harmonics specified by the user on the AXIC card. This converted information is added to any existing information on data blocks GEØM1, GEØM2, GEØM3 and GEØM4.

The fourth part of the input file processor (IFP4) converts the information on the fluid related cards (AXIF, BDYLIST, CFLUID2, CFLUID3, CFLUID4, DMIAX, FLSYM, FREEPT, FSLIST, GRIDB, PRESPT, and RINGFL) to reflect the desired harmonics, boundaries, and matrix input. This converted information is added to GEØM1, GEØM2, GEØM4, and MATPØØL.

The fifth part of the input file processor (IFP5) converts the information on the acoustic cavity related cards (AXSLØT, CAXIF2, CAXIF3, CAXIF4, CSLØT3, CSLØT4, GRIDF, GRIDS, and SLBDY) to equivalent structural scalar points, elements, scalar springs and plotting elements. This converted information is added to the GEØM1 and GEØM2 data blocks.

3.1.2 Functional Modules and Supporting DMAP Operations

The DMAP listings for the rigid formats currently included in NASTRAN are presented in the following sections. The mnemonics for the major functional modules are circled on the DMAP listings for ease of identification. Each major functional module is usually preceded and/or succeeded by several supporting DMAP operations. Brief descriptions of the operations in the functional modules are given for each of the rigid formats. The complete details for each functional module are given in the Programmer's Manual. Additional information is also given in the Theoretical Manual. The format of a functional module DMAP instruction is given in Section 5.

Many of the executive modules in the following list appear repeatedly in the rigid formats. Since the purpose of many of these operations in a rigid format is obvious, they are frequently omitted from the descriptions of the DMAP operations in the following sections. More complete descriptions of the executive modules are given in Section 5.

1. BEGIN indicates the beginning of the DMAP sequence constituting the rigid format.
2. FILE makes declarations relative to a particular file.

ABC = TAPE states that file ABC will be assigned to a physical tape if one is available.

DEF = APPEND states that file DEF may be extended as the result of an internal loop in the rigid format.

GHI = SAVE states that file GHI should not be dropped after use as it may be needed for subsequent executions of an internal loop.
3. CHKPNT specifies a list of files to be written on the new problem tape, including files that may have been purged, either because they were not generated in this particular execution or were explicitly purged with a PURGE statement.
4. LABEL specifies a labeled point in the sequence of DMAP instructions. Labels are referenced by REPT, JUMP and CEND instructions.
5. REPT specifies the end of a loop. The variable field contains the label name for the beginning of the loop and the number of times the loop is to be repeated.
6. JUMP specifies an unconditional transfer to the label indicated.
7. CEND specifies a conditional transfer to the label indicated based on the value of the parameter named. The transfer occurs if the parameter value is negative.
8. SAVE specifies variable parameter values that are to be saved for future use.
9. PURGE specifies the names of files that are conditionally dropped based on the parameter named.
10. EQUIV specifies the names of files that are conditionally equivalenced based on the parameter named.
11. END indicates the end of the DMAP sequence constituting the rigid format and causes a normal termination when executed.

3.1.3 Restart Procedures

Scheduled exits can be requested at any point in a rigid format by means of the ALTER feature. An exit is scheduled by inserting the following cards in the Executive Control Deck:

ALTER K1

EXIT K2

ENDALTER

K1 = DMAP statement number after which exit will take place.

K2 = Number of times EXIT instruction will be skipped before being executed - default is zero. For use with loops, where user wishes to execute the loop K2 times before scheduling the exit.

If the user chooses to restart the problem without making any changes, the Executive System will execute an unmodified restart following the last completed checkpoint.

Unscheduled exits are usually caused by errors on input cards or errors in the structural model resulting from missing or inconsistent input data. When such errors are detected, an unscheduled exit is performed accompanied with the output of the applicable user error messages. Following the correction of the input data errors, a modified restart can be performed.

Unscheduled exits may also occur because of machine failure or insufficient time allowance. In these cases, an unmodified restart is usually made following the last completed checkpoint. In some cases, where a portion of the problem has been completed, including the output for the completed portion, a modified restart must be made following an unscheduled exit due to insufficient time allowance. These situations are discussed under case control requirements in the sections dealing with the individual rigid formats.

The initial execution of any problem must be made with a complete NASTRAN Data Deck, including all of the bulk data. However, all or part of the bulk data may be assembled from alternate input sources, such as the User's Master File or a module written by the user to generate input. The User's Master File is described in Section 2.5 and user generated input is discussed in Section 2.6.

A New Problem Tape is constructed only when checkpointing (CHKPNT) is requested in the Executive Control Deck. The New Problem Tape should be assigned to a physical tape or other storage device that can be dismounted and saved at the conclusion of the execution. At the completion of an initial execution, the New Problem Tape contains the input deck, with the

bulk data in sorted form, and all of the files that were checkpointed during the execution.

For restarts, the Old Problem Tape is defined as the Problem Tape that was written during the previous execution. The New Problem Tape is defined as the Problem Tape written during the current execution, beginning with the restart. At the completion of an unmodified restart the New Problem Tape contains the input deck, with the bulk data in sorted form, all files from the Old Problem Tape that are necessary to complete the solution, and all of the files checkpointed during the current execution. At the completion of a modified restart, the New Problem Tape is similar, except the input deck is modified according to the information submitted for the restart.

For restarts, the Bulk Data Deck consists only of delete cards (see Section 2.4) and new cards which the user wishes to add. The previous Bulk Data Deck is read from the Old Problem Tape. All other parts of the NASTRAN Data Deck, including the Executive Control Deck, the Case Control Deck, the BEGIN BULK card and the ENDDATA card must be resubmitted even though no changes are made in the control decks and no new bulk data is added. In addition, the RESTART cards punched during the previous execution must be included in the Executive Control Deck. When changing rigid formats, the solution number (SOL) must be changed to the number of the new rigid format.

Any changes in the Case Control Deck associated with bulk data selection or subcase definition, or changes in the Bulk Data Deck, in the form of deletions or additions, mark the restart as being modified. If no such changes are made, the Executive System performs an unmodified restart at the last completed checkpoint. If only changes have been made in the output requests, the restart is considered unmodified. However, some modules preceding the last completed checkpoint may have to be executed in order to prepare the output.

For modified restarts, a number of previously executed DMAP instructions may have to be re-executed, depending on the nature of the modifications made by the user. The DMAP instructions that need to be executed in a modified restart are automatically determined within the program by comparing all changes made in Case Control cards and Bulk Data cards with the restart tables that are part of each rigid format (see Section 10 of the Programmer's Manual). In addition, if the previous execution terminated prior to completion on the same rigid format, all DMAP instructions beyond the last completed checkpoint are executed on restart.

3.1.4 Rigid Format Output

Although most of the rigid format output is optional, some of the printer output is automatic.

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The printer output is designed for 132 characters per line, with the lines per page controlled by the LINE card in the Case Control Deck. The LINE default is set to fit on 11-inch paper. Optional titles are printed at the top of each page from information in the Case Control Deck. These titles may be defined at the subcase level. The pages are automatically dated and numbered.

The output from data recovery and plot modules is all optional, and its selection is controlled by cards in the Case Control Deck. The details of making selections in the Case Control Deck are described in Section 2.3 for printer and punch output, and in Section 4 for plotter output. Since the outputs from the data recovery and plot modules vary considerably with the rigid format, a list of available output is included in the section on the Case Control Deck for each rigid format. Information on the force and stress output available for each element type is given in Section 1.3.

The first part of the output for a NASTRAN run is prepared during the execution of the Preface, prior to the beginning of the DMAP sequence of the rigid format. The following output is either automatically or optionally provided during the execution of the Preface:

1. NASTRAN title page - one full page automatic unless changed with the TITLEOPT parameter on the NASTRAN card before the Executive Control Deck.
2. Executive Control Deck echo - automatic.
3. Case Control Deck echo - automatic.
4. Unsorted Bulk Data Deck echo - optional, selected in Case Control Deck with the ECHO Card.
5. Sorted Bulk Data Deck echo - automatic, unless suppressed in the Case Control Deck with the ECHO Card.
6. DMAP listing - Selected with DIAG 14 in the Executive Control Deck. Provides the list of DMAP instructions, including alters, for the subset of the rigid format being executed.
7. Checkpoint Dictionary - automatic, when operating in the checkpoint mode. A printed echo (unless suppressed with the DIAG 9 card in the Executive Control Deck) and the punched cards are prepared for additions to the checkpoint dictionary after the execution of each checkpoint.

When making restarts, the following additional output is automatically prepared during the execution of the Preface:

1. Asterisks are placed beside the DMAP statement numbers of all instructions marked for execution by the Card Name Table in the case of modified restarts, and by the Rigid Format Change Table in the case of restarts on different rigid formats.
2. Message indicating the bit position activated by a rigid format change.
3. Table indicating, among other things, the card names and the associated "packed bit positions" activated by modifications in the NASTRAN Data Deck. The reader is referred to the Programmer's Manual for the interpretation of the rest of this table.

RIGID FORMATS

4. A list of files, along with the DMAP instructions that were marked for execution by the File Name Table.
5. List of files from the Old Problem Tape, including purged files, used to initiate the restart.

A number of fatal errors are detected by DMAP statements in the various rigid formats. The messages associated with these errors are documented in Section 6.1. These messages indicate the presence of fatal user errors that, either cannot be determined by the functional modules, or they can be more effectively detected by DMAP statements in the rigid format.

NASTRAN diagnostic messages are usually identified by number and documented in Section 6.2. These messages may be either program diagnostics or user diagnostics, and they may contain information, warnings, or an indication of a fatal error. There are also a few unnumbered, self-explanatory messages, for example, the time that the execution of each functional module begins and ends.

The Grid Point Singularity Table (GPST) is automatically output following the execution of the Grid Point Singularity Processor (GPSP) if singularities remain in the stiffness matrix at the grid point level. This table contains all possible combinations of single-point constraints, in the global coordinate system, that can be used to remove the singularities. Entries in this table should only be treated as warnings, because it cannot be determined at the grid point level whether or not the singularities are removed by other means, such as general elements or multi-point constraints. Further information on this matter is given in the Theoretical Manual.

Several items of output are discussed in other sections. Automatic output that is not associated with all of the rigid formats is discussed in the sections treating the individual rigid formats. Some output is under the control of PARAM cards. These items are discussed in Section 2.4 (PARAM card). The DIAG card is used to control the printing of some output. A list of the available output under DIAG control is given in the description of the executive control cards in Section 2.2.1.

Any of the matrices or tables that are prepared by the functional modules can be printed by using selected utility modules described in Section 5.5. These utility modules can be scheduled at any point in the rigid format by using the ALTER feature. In general, they should be scheduled immediately after the functional module that generates the table or matrix to be printed. Note that functional modules cannot be separated from a SAVE instruction. However, the user is cautioned to check the calling sequence for the utility module, in order to be certain that all required inputs have been generated prior to this point.

STATIC ANALYSIS

3.2 STATIC ANALYSIS

3.2.1 DMAP Sequence for Static Analysis

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 1

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NO.1 STATIC ANALYSIS - SERIES N $
2 FILE       OPTP2=SAVE/EST1=SAVE $
3 FILE       QG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE $
4 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/ V,N,
              NUGPDT/V,N,ALWAYS=-1 $
5 SAVE       LUSET $
6 CHKPNT     GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
7 GP2        GEOM2,EQEXIN/ECT $
8 CHKPNT     ECT $
9 PARAML     PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
10 PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
11 COND      P1,NOPCDB $
12 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
              JUMPLOT=-1 $
13 SAVE      NSIL,JUMPLOT $
14 PRTMSG     PLTSETX// $
15 PARAM      //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
16 PARAM      //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
17 COND      P1,JUMPLOT $
18 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPLOT/V,N,PLTFLG/V,N,PFILE $
19 SAVE      JUMPLOT,PLTFLG,PFILE $
20 PRTMSG     PLOTX1// $
21 LABEL     P1 $
22 CHKPNT     PLTPAR,GPSETS,ELSETS $
23 GP3        GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV/V,N,NEVER=1 $
24 SAVE      NOGRAV $
25 PARAM      //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRUPNT=-1 $
26 CHKPNT     SLT,GPTT $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 1

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

```

27 TAL      ECT,EPT,8GPDOT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/  V,N,
      NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

28  SAVE      NOSIMP,NOGENL,GENEL $

29  PARAM      //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $

30  COND      ERROR4,NOELMT $

31  PURGE      KGGX,GPST/NOSIMP/OGPST/GENEL $

32  CHKPNT     EST,GPECT,GEI,GPST,OGPST $

33 OPTPR1    MPT,EPT,ECT,DIT,EST/OPTP1/V,N,PRINT/V,N,TSTART/V,N,COUNT $

34  SAVE      PRINT,TSTART,COUNT $

35  CHKPNT     OPTP1 $

36  PARAM      //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

37  JUMP      LOOPTOP $

```

Top of Optimization Loop

```

38  LABEL      LOOPTOP $

39  COND      LBL1,NOSIMP $

40  PARAM      //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

41  EQUIV      OPTP1,OPTP2/NEVER/EST,EST1/NEVER $

42 EMG      EST,CSTM,MPT,DIT,GEUM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
      N,NUMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
      CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
      CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

43  SAVE      NOKGGX,NUMGG $

44  CHKPNT     KELM,KDICT,MELM,MDICT $

45  COND      JMPKGG,NOKGGX $

46 EMA      GPECT,KDICT,KELM/KGGX,GPST $

47  CHKPNT     KGGX,GPST $

48  LABEL      JMPKGG $

49  COND      JMPMGG,NUMGG $

50 EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

51  CHKPNT     MGG $

52  LABEL      JMPMGG $

```

STATIC ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 1

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

53	COND	LBL1,GRDPNT \$
54	COND	ERROR2,NUMGG \$
55	GPWG	BGPD, CSTM, EQEXIN, MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS \$
56	DFP	OGPWG,,,,,// \$
57	LABEL	LBL1 \$
58	EQUIV	KGGX,KGG/NOGENL \$
59	CHKPNT	KGG \$
60	COND	LBL11A,NOGENL \$
61	SMA3	GE1,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NUSIMP \$
62	CHKPNT	KGG \$
63	LABEL	LBL11A \$
64	PARAM	//C,N,MPY/V,N,NSKIP/C,N,O/C,N,O \$
65	JUMP	LBL11 \$
<hr/>		
66	LABEL	LBL11 \$
67	GP4	CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPD,CSTM/RG,YS,USET,ASET/V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NUSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
68	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NUSET,NOL,NOA \$
69	COND	ERROR3,NOL \$
70	PARAM	//C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT \$
71	PURGE	KRR,KLR,QR,DM/REACT/GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS, KFS,KSS/SINGLE/QG/NOSR \$
72	CHKPNT	KRR,KLR,QR,DM,GM,GO,KOO,LOO,PO,UOOV,RUOV,PS,KFS,KSS,QG,USET,RG, YS,ASET \$
73	COND	LBL4,GENEL \$
74	GPSP	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
75	SAVE	NOGPST \$
76	COND	LBL4,NOGPST \$
77	DFP	OGPST,,,,,// \$
78	LABEL	LBL4 \$

Top of DMAP Loop

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 1

N A S T-R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

79	EQUIV	KGG,KNN/MPCF1 \$
80	CHKPNT	KNN \$
91	COND	LBL2,MPCF2 \$
82	MCE1	USET,RG/GM \$
83	CHKPNT	GM \$
84	MCE2	USET,GM,KGG,,,/KNN,,, \$
85	CHKPNT	KNN \$
86	LABEL	LBL2 \$
87	EQUIV	KNN,KFF/SINGLE \$
88	CHKPNT	KFF \$
89	COND	LBL3,SINGLE \$
90	SCE1	USET,KNN,,,/KFF,KFS,KSS,,, \$
91	CHKPNT	KFS,KSS,KFF \$
92	LABEL	LBL3 \$
93	EQUIV	KFF,KAA/UMIT \$
94	CHKPNT	KAA \$
95	COND	LBL5,UMIT \$
96	SMP1	USET,KFF,,,/GO,KAA,KOU,LOO,,,,, \$
97	CHKPNT	GU,KAA,KOU,LOO \$
98	LABEL	LBL5 \$
99	EQUIV	KAA,KLL/REACT \$
100	CHKPNT	KLL \$
101	COND	LBL6,REACT \$
102	RBMG1	USET,KAA,/KLL,KLR,KRR,,, \$
103	CHKPNT	KLL,KLR,KRR \$
104	LABEL	LBL6 \$
105	RBMG2	KLL/LLL \$
106	CHKPNT	LLL \$

STATIC ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 1

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

107	COND	LBL7, REACT \$
108	RBMG3	LLL, KLR, KRR/DM \$
109	CHKPNT	DM \$
110	LABEL	LBL7 \$
111	SSG1	SLT, BGPDT, CSTM, SIL, EST, MPT, GPTT, EDT, MGG, CASECC, DIT/PG/V, N, LUSET/V, N, NSKIP \$
112	CHKPNT	PG \$
113	EQUIV	PG, PL/NUSET \$
114	CHKPNT	PL \$
115	COND	LBL10, NUSET \$
116	SSG2	USET, GM, YS, KFS, GO, DM, PG/QR, PO, PS, PL \$
117	CHKPNT	QR, PO, PS, PL \$
118	LABEL	LBL10 \$
119	SSG3	LLL, KLL, PL, LOO, KOO, PO/ULV, UOOV, RULV, RUOV/V, N, OMIT/V, Y, IRES=-1/ V, N, NSKIP/V, N, EPSI \$
120	SAVE	EPSI \$
121	CHKPNT	ULV, UOOV, RULV, RUOV \$
122	COND	LBL9, IRES \$
123	MATGPR	GPL, USET, SIL, RULV//C, N, L \$
124	MATGPR	GPL, USET, SIL, RUOV//C, N, D \$
125	LABEL	LBL9 \$
126	SDR1	USET, PG, ULV, UOOV, YS, GO, GM, PS, KFS, KSS, QR/UGV, PGG, QG/V, N, NSKIP/ C, N, STATICS \$
127	CHKPNT	UGV, PGG, QG \$
128	COND	LBL8, REPEAT \$
129	REPT	LBL11, 100 \$
130	JUMP	ERROR1 \$
131	PARAM	//C, N, NOT/V, N, TEST/V, N, REPEAT \$
132	COND	ERROR5, TEST \$
133	LABEL	LBL8 \$

Bottom of DMAP Loop

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 1

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

134	CHKPNT	CSTM \$
135	GPFOR	CASECC,UGV,KELM,KDICT,ECT,EQEXIN,GPECT,PGG,QG/ONRGY1,OGPFB1/ C,N,STATICS \$
136	UFP	ONRGY1,OGPFB1,,,// \$
137	SDR2	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPD, ,QG,UGV,EST,,PGG/ OPG1,OQG1,OUGV1,OES1,DEF1,PUGV1/C,N,STATICS/V,N,NOSORT2=-1 \$
138	SAVE	NOSORT2 \$
139	COND	LBL17,NOSORT2 \$
140	SDR3	OUGV1,OPG1,OQG1,DEF1,OES1,/OUGV2,OPG2,OQG2,DEF2,OES2, \$
141	OFF	OUGV2,OPG2,OQG2,DEF2,OES2, //V,N,CARDNO \$
142	SAVE	CARDNO \$
143	XYTRAN	XYCDB,OPG2,OQG2,OUGV2,OES2,DEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N, PFILE/V,N,CARDNO \$
144	SAVE	PFILE,CARDNO \$
145	XYPLGT	XYPLTT// \$
146	JUMP	DPLT \$
147	LABEL	LBL17 \$
148	COND	LBLOFP,COUNT \$
149	OPTPR2	OPTP1,OES1,EST/OPTP2,EST1/V,N,PRINT/V,N,TSTART/V,N,COUNT/V,N, CARDNO \$
150	SAVE	CARDNO,COUNT,PRINT \$
151	EQUIV	EST1,EST/ALWAYS/OPTP2,OPTP1/ALWAYS \$
152	COND	LOOPEND,PRINT \$
153	LABEL	LBLOFP \$
154	OFF	OUGV1,OPG1,OQG1,DEF1,OES1, //V,N,CARDNO \$
155	SAVE	CARDNO \$
156	COND	P2,JUMPPLT \$
157	LABEL	DPLT \$
158	PLOT	PLTPAR,CPSETS,ELSETS,CASECC,BGPD,EQEXIN,SIL,PUGV1,,GPECT,OES1/ PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLT/V,N,PLTFLG/V,N,PFILE \$
159	SAVE	PFILE \$

STATIC ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 1

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

```
160  PRMSG    PLUTX2// $
161  LABEL    P2 $
162  LABEL    LOOPEND $
163  COND     FINIS,COUNT $
164  REPT     LOOPTOP,100 $
165  JUMP     FINIS $
166  LABEL    ERROR1 $
167  PRTPARM  //C,N,-1/C,N,STATICS $
168  LABEL    ERROR2 $
169  PRTPARM  //C,N,-2/C,N,STATICS $
170  LABEL    ERROR3 $
171  PRTPARM  //C,N,-3/C,N,STATICS $
172  LABEL    ERROR4 $
173  PRTPARM  //C,N,-4/C,N,STATICS $
174  LABEL    ERROR5 $
175  PRTPARM  //C,N,-5/C,N,STATICS $
176  LABEL    FINIS $
177  END      $
```

Bottom of
Optimization Loop

RIGID FORMATS

3.2.2 Description of DMAP Operations for Static Analysis

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
7. GP2 generates Element Connection Table with internal indices.
11. Go to DMAP No. 21 if no plot package is present.
12. PLTSET transforms user input into a form used to drive structure plotter.
14. PRTMSG prints error messages associated with structure plotter.
17. Go to DMAP No. 21 if no undeformed structure plot request.
18. PLØT generates all requested undeformed structure plots.
20. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
23. GP3 generates Static Loads Table and Grid Point Temperature Table.
27. TA1 generates element tables for use in matrix assembly and stress recovery.
30. Go to DMAP No. 172 and print error message if no elements have been defined.
33. ØPTPR1 performs phase one property optimization and initialization check.
37. Go to next DMAP instruction if cold start or modified restart. LØØPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.
38. Beginning of Loop for property optimization.
39. Go to DMAP No. 57 if there are no structural elements.
42. EMG generates structural element matrix tables and dictionaries for later assembly.
45. Go to DMAP No. 48 if no stiffness matrix is to be assembled.
46. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
49. Go to DMAP No. 52 if no mass matrix is to be assembled.
50. EMA assembles mass matrix $[M_{gg}]$.
53. Go to DMAP No. 57 if no weight and balance request.
54. Go to DMAP No. 168 and print error message if no mass matrix exists.
55. GPWG generates weight and balance information.
56. ØFP formats weight and balance information and places it on the system output file for printing.
58. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
60. Go to DMAP No. 63 if no general elements.
61. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
65. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

STATIC ANALYSIS

66. Beginning of Loop for additional constraint sets
67. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g] \{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.
69. Go to DMAP No. 170 and print error message if no independent degrees of freedom are defined.
73. Go to DMAP No. 78 if general elements present.
74. GPSP determines if possible grid point singularities remain.
76. Go to DMAP No. 78 if no grid point singularities remain.
77. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.
79. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.
81. Go to DMAP No. 86 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
82. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
84. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] .$$

87. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.
89. Go to DMAP No. 92 if no single-point constraints.
90. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array} \right] .$$

93. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.
95. Go to DMAP No. 98 if no omitted coordinates.
96. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right] ,$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o] .$

RIGID FORMATS

99. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

101. Go to DMAP No. 104 if no free-body supports.

102. RBMG1 partitions out-free body supports

$$[K_{aa}] = \begin{bmatrix} K_{\ell\ell} & K_{\ell r} \\ K_{r\ell} & K_{rr} \end{bmatrix}$$

105. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

107. Go to DMAP No. 110 if no free-body supports.

108. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}]$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D]$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}$$

111. SSG1 generates static load vectors $\{P_g\}$.

113. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

116. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ P_m \end{Bmatrix}, \quad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\}$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ P_s \end{Bmatrix}, \quad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{P_s\}$$

$$\{P_f\} = \begin{Bmatrix} \bar{P}_a \\ P_o \end{Bmatrix}, \quad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\}$$

$$\{P_a\} = \begin{Bmatrix} P_\ell \\ P_r \end{Bmatrix}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

STATIC ANALYSIS

119. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^0\} = [K_{oo}]^{-1}\{P_o\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} ,$$

$$\epsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^0\} ,$$

$$\epsilon_o = \frac{\{u_o^0^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^0\}}$$

122. Go to DMAP No. 125 if residual vectors are not to be printed.

123. MATGPR prints the residual vector for independent coordinates (RULV)

124. MATGPR prints the residual vector for omitted coordinates (RUØV).

126. SDR1 recovers dependent displacements

$$\begin{pmatrix} u_\ell \\ u_r \end{pmatrix} = \{u_a\} , \quad \{u_o\} = [G_o]\{u_a\} + \{u_o^0\} ,$$

$$\begin{pmatrix} u_a \\ u_o \end{pmatrix} = \{u_f\} , \quad \begin{pmatrix} u_f \\ y_s \end{pmatrix} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\} , \quad \begin{pmatrix} u_n \\ u_m \end{pmatrix} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{y_s\}.$$

128. Go to DMAP No. 133 if all constraint sets have been processed.

129. Go to DMAP No. 66 if additional sets of constraints need to be progressed.

130. Go to DMAP No. 166 and print error message if number of loops exceeds 100.

132. Go to DMAP No. 174 and print error message if multiple boundary conditions are attempted with improper subset.

RIGID FORMATS

135. GPFDR calculates for requested sets the grid point force balance and element strain energy for output.
136. ØFP formats the tables prepared by GPFDR and places them on the system output file for printing
137. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).
139. Go to DMAP No. 147 if no output requests for grid point number or element number sort.
140. SDR3 prepares requested output sorted by grid point number or element number.
141. ØFP formats requested output sorted by grid point number or element number and places it on the system output file for printing.
143. XYTRAN prepares the input for requested X-Y plots.
145. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. subcase.
146. Go to DMAP No. 157.
148. Go to DMAP No. 153 if no phase two property optimization.
149. ØPTPR2 performs phase two property optimization.
151. Equivalence EST1 to EST and ØPTP2 to ØPTP1 everytime this instruction is executed.
152. Go to DMAP No. 162 if no additional output is to be printed for this loop.
154. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.
156. Go to DMAP No. 161 if no deformed structure plots are requested.
158. PLØT generates all requested deformed structure plots.
160. PRTMSG prints plotter data and engineering data for each deformed plot generated.
163. Go to DMAP No. 176 and make a normal exit if property optimization is complete.
164. Go to DMAP No. 38 if additional loops for property optimization are needed.
165. Go to DMAP No. 176 and make normal exit.
167. STATIC ANALYSIS ERROR MESSAGE NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.
169. STATIC ANALYSIS ERROR MESSAGE NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIONS.
171. STATIC ANALYSIS ERROR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.
173. STATIC ANALYSIS ERROR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.
175. STATIC ANALYSIS ERROR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

STATIC ANALYSIS

3.2.3 Case Control Deck and Parameters for Static Analysis

The following items relate to subcase definition and data selection for Static Analysis:

1. A separate subcase must be defined for each unique combination of constraints and static loads.
2. A static loading condition must be defined for (not necessarily within) each subcase with a `LØAD`, `TEMPERATURE(LØAD)`, or `DEFØRM` selection unless all loading is specified with grid point displacements on `SPC` cards.
3. An `SPC` set must be selected for (not necessarily within) each subcase, unless the model is a properly supported free body, or all constraints are specified on `GRID` cards, `Scalar Connection` cards, or with `General Elements`.
4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.
5. `REPCASE` may be used to repeat subcases in order to allow multiple sets of the same output item.

The following printed output, sorted by loads (`SØRT1`) or by grid point number or element number (`SØRT2`), may be requested for Static Analysis solutions:

1. Displacements and components of static loads and single-point forces of constraint at selected grid points or scalar points.
2. Forces and stresses in selected elements.

The following plotter output may be requested for Static Analysis solutions:

1. Undeformed and deformed plots of the structural model.
2. X-Y plot of any component of displacement, static load, or single-point force of constraint for a grid point or scalar point versus subcase.
3. X-Y plot of any stress or force component for an element versus subcase.

The following parameters are used in Static Analysis:

1. `GRDPNT` - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

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2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMG.
3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.
4. C0UPMASS - CPBAR, CPR0D, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices, rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.2.4 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Static Analysis, Rigid Format 1, are altered for automatic substructure analyses:

Phase 1: 69, 100-110, 115-161

Phase 2: 4-5, 9-22, 29-30, 41, 58-61, 73-78, 134-164

Phase 3: 100-110, 115-125, 127

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

STATIC ANALYSIS WITH INERTIA RELIEF

3.3 STATIC ANALYSIS WITH INERTIA RELIEF

3.3.1 DMAP Sequence for Static Analysis with Inertia Relief

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 2

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NO.2 STATIC ANALYSIS WITH INERTIA RELIEF - SERIES N $
2 FILE       QG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE/MNN=SAVE $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL/V,N,LUSET/ V,N,
              NOGPD,T $
4 SAVE       LUSET $
5 CHKPNT     GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL $
6 GP2        GEOM2,EQEXIN/ECT $
7 CHKPNT     ECT $
8 PARAML     PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
9 PURGE      PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
10 COND      P1,NOPCDB $
11 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
              JUMPPLOT=-1 $
12 SAVE      NSIL,JUMPPLOT $
13 PRTMSG     PLTSETX// $
14 PARAM      //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
15 PARAM      //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
16 COND      P1,JUMPPLOT $
17 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPD,T,EQEXIN,SIL,,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
18 SAVE      JUMPPLOT,PLTFLG,PFILE $
19 PRTMSG     PLOTX1// $
20 LABEL      P1 $
21 CHKPNT     PLTPAR,GPSETS,ELSETS $
22 GP3        GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $
23 CHKPNT     SLT,GPTT $
24 TA1        ECT,EPT,BGPD,T,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N,

```

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RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 2

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

	NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL \$
25	SAVE NOSIMP,NOGENL,GENEL \$
26	COND ERROR1,NOSIMP \$
27	PURGE OGPST/GENEL \$
28	CHKPNT EST,GPECT,GEI,OGPST \$
29	PARAM //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
30	PARAM //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 \$
31	EMG EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V, N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
32	SAVE NOKGGX,NOMGG \$
33	CHKPNT KELM,KDICT,MELM,MDICT \$
34	COND JMPKGG,NOKGGX \$
35	EMA GPECT,KDICT,KELM/KGGX,GPST \$
36	CHKPNT KGGX,GPST \$
37	LABEL JMPKGG \$
38	COND ERROR1,NOMGG \$
39	EMA GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
40	CHKPNT MGG \$
41	COND LGPWG,GRDPNT \$
42	GPWG BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS \$
43	DFP OGPWG,,,,,// \$
44	LABEL LGPWG \$
45	EQUIV KGGX,KGG/NOGENL \$
46	CHKPNT KGG \$
47	COND LBL11A,NOGENL \$
48	SMA3 GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

49	CHKPNT	KGG \$	
50	LABEL	LBL11A \$	
51	PARAM	//C,N,MPY/V,N,NSKIP/C,N,O/C,N,O \$	
52	JUMP	LBL11 \$	
53	LABEL	LBL11 \$	Top of DMAP Loop
54	GP4	CASECC,GEOM4,EQEXIN,SIL,GPD,T,BGPD,T,CSTM/RG,YS,USET,ASET/V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$	
55	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA \$	
56	COND	ERROR3,NOL \$	
57	COND	ERROR4,REACT \$	
58	PURGE	GM/MPCF1/GO,KOO,LOO,MOO,MOA,PO,UOOV,RUOV/OMIT/KSS,KFS,PS/ SINGLE \$	
59	CHKPNT	GM,RG,GO,KOO,LOO,MOO,MOA,PO,KSS,KFS,YS,PS,USET,ASET,RUOV \$	
60	COND	LBL4,GENEL \$	
61	GPSP	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$	
62	SAVE	NOGPST \$	
63	COND	LBL4,NOGPST \$	
64	OFF	OGPST,,,,,//\$	
65	LABEL	LBL4 \$	
66	EQUIV	KGG,KNN/MPCF1/MGG,MNN/MPCF1 \$	
67	CHKPNT	KNN,MNN \$	
68	COND	LBL2,MPCF2 \$	
69	MCE1	USET,RG/GM \$	
70	CHKPNT	GM \$	
71	MCE2	USET,GM,KGG,MGG,,/KNN,MNN,, \$	
72	CHKPNT	KNN,MNN \$	
73	LABEL	LBL2 \$	

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

74	EQUIV	KNN,KFF/SINGLE/MNN,MFF/SINGLE \$
75	CHKPNT	KFF,MFF \$
76	COND	LBL3,SINGLE \$
77	(SCE1)	USET,KNN,MNN,,/KFF,KFS,KSS,MFF,, \$
78	CHKPNT	KFS,KSS,KFF,MFF \$
79	LABEL	LBL3 \$
80	EQUIV	KFF,KAA/OMIT/ MFF,MAA/OMIT \$
81	CHKPNT	KAA,MAA \$
82	COND	LBL5,OMIT \$
83	(SMP1)	USET,KFF,MFF,,/GO,KAA,KOC,LOO,MAA,MOO,MOA,, \$
84	CHKPNT	GO,KAA,KOC,LOO,MAA,MOO,MOA \$
85	LABEL	LBL5 \$
86	(RBMG1)	USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR \$
87	CHKPNT	KLL,KLR,KRR,MLL,MLR,MRR \$
88	(RBMG2)	KLL/LLL \$
89	CHKPNT	LLL \$
90	(RBMG3)	LLL,KLR,KRR/DM \$
91	CHKPNT	DM \$
92	(RBMG4)	DM,MLL,MLR,MRR/MR \$
93	CHKPNT	MR \$
94	(SSG1)	SLT,BGPD,T,CSTM,SIL,EST ,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N, LUSET/V,N,NSKIP \$
95	CHKPNT	PG \$
96	(SSG2)	USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL \$
97	CHKPNT	QR,PO,PS,PL \$
98	(SSG4)	PL,QR,PO,MR,MLR,DM,MLL,MOO,MOA,GO,USET/PLI,POI/V,N,OMIT \$
99	CHKPNT	PLI,POI \$

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RIGID FORMAT DMAP LISTING
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RIGID FORMAT 2

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

100	(SSG3)	LLL,KLL,PLI,LOO,KOO,POI/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y, IRES=-1/V,N,NSKIP/V,N,EPSI \$
101	SAVE	EPSI \$
102	CHKPNT	ULV,UOOV,RULV,RUOV \$
103	COND	LBL9,IRES \$
104	MATGPR	GPL,USET,SIL,RULV//C,N,L \$
105	MATGPR	GPL,USET,SIL,RUOV//C,N,O \$
106	LABEL	LBL9 \$
107	(SDR1)	USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QG/V,N,NSKIP/ C,N,STATICS \$
108	CHKPNT	UGV,QG,PGG \$
109	COND	LBL8,REPEAT \$
110	REPT	LBL11,100 \$
111	JUMP	ERROR2 \$
112	PARAM	//C,N,NOT/V,N,TEST/V,N,REPEAT \$
113	COND	ERROR5,TEST \$
114	LABEL	LBL8 \$
115	CHKPNT	CSTM \$
116	(SDR2)	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDOT,,QG,UGV,EST,,PGG/ OPG1,UQG1,UGV1,OES1,DEF1,PUGV1/C,N,STATICS \$
117	PARAM	//C,N,MPY/V,N,CARDNO/C,N,O/C,N,O \$
118	OFP	UGV1,OPG1,OQG1,DEF1,OES1,//V,N,CARDNO \$
119	SAVE	CARDNO \$
120	COND	P2,JUMPPLOT \$
121	(PLOT)	PLTPAR,GPSETS,ELSETS,CASECC,BGPDOT,EQEXIN,SIL,PUGV1,,GPECT,OES1/ PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
122	SAVE	PFILE \$
123	PRTMSG	PLOTX2// \$

Bottom of DMAP Loop

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```
124 LABEL      P2 $
125 JUMP       FINIS $
126 LABEL      ERROR1 $
127 PRTPARM    //C,N,-1/C,N,INERTIA $
128 LABEL      ERROR2 $
129 PRTPARM    //C,N,-2/C,N,INERTIA $
130 LABEL      ERROR3 $
131 PRTPARM    //C,N,-3/C,N,INERTIA $
132 LABEL      ERROR4 $
133 PRTPARM    //C,N,-4/C,N,INERTIA $
134 LABEL      ERROR5 $
135 PRTPARM    //C,N,-5/C,N,INERTIA $
136 LABEL      FINIS $
137 END        $
```

STATIC ANALYSIS WITH INERTIA RELIEF

3.3.2 Description of DMAP Operations for Static Analysis with Inertia Relief

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
6. GP2 generates Element Connection Table with internal indices.
10. Go to DMAP No. 20 if no plot package is present.
11. PLTSET transforms user input into a form used to drive structure plotter.
13. PRTMSG prints error messages associated with structure plotter.
16. Go to DMAP No. 20 if no undeformed structure plot request.
17. PLØT generates all requested undeformed structure plots.
19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
22. GP3 generates Static Loads Table and Grid Point Temperature Table.
24. TA1 generates element tables for use in matrix assembly and stress recovery.
26. Go to DMAP No. 126 and print error message if there are no structure elements.
31. EMG generates structural element matrix tables and dictionaries for later assembly.
34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.
35. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
38. Go to DMAP No. 126 and print error message if no mass matrix exists.
39. EMA assembles mass matrix $[M_{gg}]$.
41. Go to DMAP No. 44 if no weight and balance request.
42. GPWG generates weight and balance information.
43. ØFP formats weight and balance information and places it on the system output file for printing.
45. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
47. Go to DMAP No. 50 if no general elements.
48. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
52. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.
53. Beginning of Loop for additional constraint sets.
54. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.
56. Go to DMAP No. 130 and print error message if no independent degrees of freedom are defined.
57. Go to DMAP No. 132 and print error message if no free-body supports.

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60. Go to DMAP No. 65 if general elements present.
61. GPSP determines if possible grid point singularities remain.
63. Go to DMAP No. 65 if grid point singularities remain.
64. ØFP Formats table of possible grid point singularities and places it on the system output file for printing.
66. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.
68. Go to DMAP No. 73 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
69. MCE1 partitions multipoint constraint equations $[R_g] = [R_m; R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
71. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & K_{nm} \\ K_{mn} & K_{mm} \end{bmatrix} \quad \text{and} \quad [M_{gg}] = \begin{bmatrix} \bar{M}_{nn} & M_{nm} \\ M_{mn} & M_{mm} \end{bmatrix}$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

74. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.
76. Go to DMAP No. 79 if no single-point constraints.
77. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix}$$

80. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.
82. Go to DMAP No. 85 if no omitted coordinates.
83. SMP1 partitions constrained stiffness and mass matrices

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix} \quad \text{and} \quad [M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix},$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reductions $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

and $[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$

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86. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array} \right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array} \right].$$

88. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

90. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}$$

92. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

94. SSG1 generates static load vectors $\{P_g\}$.

96. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{ \begin{array}{c} \bar{P}_n \\ \bar{P}_m \end{array} \right\}, \quad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{ \begin{array}{c} \bar{P}_f \\ \bar{P}_s \end{array} \right\}, \quad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{P_s\},$$

$$\{P_f\} = \left\{ \begin{array}{c} \bar{P}_a \\ \bar{P}_o \end{array} \right\}, \quad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \left\{ \begin{array}{c} P_\ell \\ P_r \end{array} \right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

98. SSG4 calculates inertia loads and combines them with static loads

$$\{P_\ell^i\} = \{P_\ell\} + \left([M_{\ell\ell}][D] + [M_{\ell r}] \right) [m_r]^{-1} \{q_r\} \quad \text{and}$$

$$\{P_o^i\} = \{P_o\} + \left([M_{oo}][G_o] + [M_{ao}^T] \right) \left[\begin{array}{c} D \\ I \end{array} \right] [m_r]^{-1} \{q_r\}.$$

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100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1} \{P_\ell^i\},$$

solves for displacements of omitted coordinates

$$\{u_0^o\} = [K_{00}]^{-1} \{P_0^i\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell^i\} = \{P_\ell^i\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\epsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell^i\}}{\{P_\ell^i\}^T \{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_0^i\} = \{P_0^i\} - [K_{00}]\{u_0^o\},$$

$$\epsilon_0 = \frac{\{u_0^T\}\{\delta P_0^i\}}{\{P_0^i\}^T \{u_0^o\}}$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. Print residual vector for independent coordinates (RULV)

105. Print residual vector for omitted coordinates (RUØV).

107. SDR1 recovers dependent displacements.

$$\begin{pmatrix} u_\ell \\ u_r \end{pmatrix} = \{u_a\}, \quad \{u_0\} = [G_0]\{u_a\} + \{u_0^o\},$$

$$\begin{pmatrix} u_a \\ u_o \end{pmatrix} = \{u_f\}, \quad \begin{pmatrix} u_f \\ Y_s \end{pmatrix} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\}, \quad \begin{pmatrix} u_n \\ u_m \end{pmatrix} = \{u_g\}$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\}.$$

109. Go to DMAP No. 114 if all constraint sets have been processed.

110. Go to DMAP No. 53 if additional sets of constraints need to be processed.

111. Go to DMAP No. 128 and print error message if number of loops exceeds 100.

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113. Go to DMAP No. 134 and print error message if multiple boundary conditions are attempted with improper subset.
116. SDR2 calculates element forces and stresses ($\emptyset EF1$, $\emptyset ES1$) and prepares load vectors, displacement vectors and single-point forces of constraint for output ($\emptyset PG1$, $\emptyset UGV1$, $PUGV1$, $\emptyset QG1$).
118. $\emptyset FP$ formats tables prepared by SDR2 and places them on the system output file for printing.
120. Go to DMAP No. 124 if no deformed structure plots are requested.
121. $PL\emptyset T$ generates all requested deformed structure plots.
123. $PRTMSG$ prints plotter data and engineering data for each deformed plot generated.
125. Go to DMAP No. 136 and make normal exit.
127. STATIC ANALYSIS WITH INERTIA RELIEF ERROR MESSAGE NO. 1 - MASS MATRIX REQUIRED FOR CALCULATION OF INERTIA LOADS.
129. STATIC ANALYSIS WITH INERTIA RELIEF ERROR MESSAGE NO. 2 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.
131. STATIC ANALYSIS WITH INERTIA RELIEF ERROR MESSAGE NO. 3 - NO INDEPENDENT DEGREES OF FREEDOM HAVE BEEN DEFINED.
133. STATIC ANALYSIS WITH INERTIA RELIEF ERROR MESSAGE NO. 4 - FREE-BODY SUPPORTS ARE REQUIRED.
135. STATIC ANALYSIS WITH INERTIA RELIEF ERROR MESSAGE NO. 5 - A LOOPING PROBLEM RUN ON A NON-LOOPING SUBSET.

RIGID FORMATS

3.3.3 Case Control Deck and Parameters for Static Analysis with Inertia Relief

The following items relate to subcase definition and data selection for Static Analysis with Inertia Relief:

1. A separate subcase must be defined for each unique combination of constraints and static loads.
2. A static loading condition must be defined for (not necessarily within) each subcase with a LOAD selection.
3. An SPC set may be selected only if used to remove grid point singularities or some, but not all, of the free body motions. At least one free body support must be provided with a SUPPORT card in the Bulk Data Deck.
4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.
5. REPCASE may be used to repeat subcases in order to allow multiple sets for the same output item.

The following output may be requested for Static Analysis with Inertia Relief:

1. Displacements at selected grid points due to the sum of the applied loads and the inertia loads.
2. Nonzero components of the applied static loads at selected grid points.
3. Reactions on free-body supports due to applied loads (single-point forces of constraint).
4. Forces and stresses in selected elements due to the sum of the applied loads and inertia loads.
5. Undeformed and deformed plots of the structural model.

The following parameters are used in Static Analysis with Inertia Relief:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.

STATIC ANALYSIS WITH INERTIA RELIEF

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.
4. C0UPMASS - CPBAR, CPR0D, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.3.4 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Static Analysis with Inertia Relief, Rigid Format 2, are altered in automatic substructure analyses.

Phase 1: 57, 86-93, 96-124

Phase 2: 3-4, 8-21, 26, 38, 45-48, 60-65, 116-124

Phase 3: 86-93, 96-106, 108

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

NORMAL MODE ANALYSIS

3.4 NORMAL MODE ANALYSIS

3.4.1 DMAP Sequence for Normal Mode Analysis

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

1	BEGIN	NO.3 NORMAL MODES ANALYSIS - SERIES N \$
2	FILE	LAMA=APPEND/PHIA=APPEND \$
3	<u>GP1</u>	GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/ V,N, NOGPDT \$
4	SAVE	LUSET \$
5	CHKPNT	GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL \$
6	<u>GP2</u>	GEOM2,EQEXIN/ECT \$
7	CHKPNT	ECT \$
8	PARAML	PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB \$
9	PURGE	PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB \$
10	COND	P1,NOPCDB \$
11	PLTSET	PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N, JUMPPLOT=-1 \$
12	SAVE	NSIL,JUMPPLOT \$
13	PRTMSG	PLTSETX// \$
14	PARAM	//C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 \$
15	PARAM	//C,N,MPY/V,N,PFILE/C,N,0/C,N,0 \$
16	COND	P1,JUMPPLOT \$
17	<u>PLOT</u>	PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,/PLOTX1/ V,N, NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
18	SAVE	JUMPPLOT,PLTFLG,PFILE \$
19	PRTMSG	PLOTX1// \$
20	LABEL	P1 \$
21	CHKPNT	PLTPAR,GPSETS,ELSETS \$
22	<u>GP3</u>	GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV \$
23	CHKPNT	GPTT \$
24	<u>TA1</u>	ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N,

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 3

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION

NO.		NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL \$
25	SAVE	NOGENL,NOSIMP,GENEL \$
26	COND	ERROR1,NOSIMP \$
27	PURGE	OGPST/GENEL \$
28	CHKPNT	EST,GPECT,GEI,OGPST \$
29	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
30	PARAM	//C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 \$
31	EMG	EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V, N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
32	SAVE	NOKGGX,NOMGG \$
33	CHKPNT	KELM,KDICT,MELM,MDICT \$
34	COND	JMPKGG,NOKGGX \$
35	EMA	GPECT,KDICT,KELM/KGGX,GPST \$
36	CHKPNT	KGGX,GPST \$
37	LABEL	JMPKGG \$
38	COND	ERROR1,NOMGG \$
39	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
40	CHKPNT	MGG \$
41	COND	LGPWG,GRDPNT \$
42	GPWG	BGPD,T,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS \$
43	DFP	OGPWG,,,,,// \$
44	LABEL	LGPWG \$
45	EQUIV	KGGX,KGG/NOGENL \$
46	CHKPNT	KGG \$
47	COND	LBL11,NOGENL \$
48	SMA3	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$

NORMAL MODE ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 3

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

49	CHKPNT	KGG \$
50	LABEL	LBL11 \$
51	PARAM	//C,N,MPY/V,N,NSKIP/C,N,O/C,N,O \$
52	GP4	CASECC,GEOM4,EQEXIN,SIL,GPD,T,BGPD,T,CSTM/RG,,USET,ASET/ V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
53	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA \$
54	COND	ERROR3,NOL \$
55	PURGE	KRR,KLR,DM,MLR,MR/REACT/GM/MPCF1/GO/OMIT/KFS/SINGLE/QG/NOSET \$
56	CHKPNT	KRR,KLR,DM,MLR,MR,GM,RG,GO,KFS,QG,USET,ASET. \$
57	COND	LBL4,GENEL \$
58	GPSP	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
59	SAVE	NOGPST \$
60	COND	LBL4,NOGPST \$
61	DFP	OGPST,,,,,// \$
62	LABEL	LBL4 \$
63	EQUIV	KGG,KNN/MPCF1/MGG,MNN/MPCF1 \$
64	CHKPNT	KNN,MNN \$
65	COND	LBL2,MPCF2 \$
66	MCE1	USET,RG/GM \$
67	CHKPNT	GM \$
68	MCE2	USET,GM,KGG,MGG,,/KNN,MNN,, \$
69	CHKPNT	KNN,MNN \$
70	LABEL	LBL2 \$
71	EQUIV	KNN,KFF/SINGLE/MNN,MFF/SINGLE \$
72	CHKPNT	KFF,MFF \$
73	COND	LBL3,SINGLE \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 3

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

74	(SCE1)	USET,KNN,MNN,,/KFF,KFS,,MFF,, \$
75	CHKPNT	KFS,KFF,MFF \$
76	LABEL	LBL3 \$
77	EQUIV	KFF,KAA/OMIT \$
78	EQUIV	MFF,MAA/OMIT \$
79	CHKPNT	KAA,MAA \$
80	COND	LBL5,OMIT \$
81	(SMP1)	USET,KFF,,,/GO,KAA,KOC,LOO,,,, \$
82	CHKPNT	GO,KAA \$
83	(SMP2)	USET,GO,MFF/MAA \$
84	CHKPNT	MAA \$
85	LABEL	LBL5 \$
86	COND	LBL6,REACT \$
87	(RBMG1)	USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR \$
88	CHKPNT	KLL,KLR,KRR,MLL,MLR,MRR \$
89	(RBMG2)	KLL/LLL \$
90	CHKPNT	LLL \$
91	(RBMG3)	LLL,KLR,KRR/DM \$
92	CHKPNT	DM \$
93	(RBMG4)	DM,MLL,MLR,MRR/MR \$
94	CHKPNT	MR \$
95	LABEL	LBL6 \$
96	(DPD)	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,EED,EQDYN/V,N, LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/ N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE \$
97	SAVE	NOEED \$
98	COND	ERROR2,NOEED \$

NORMAL MODE ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

99  CHKPNT    EED $
100  PARAM     //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $
101  READ      KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $
102  SAVE      NEIGV $
103  CHKPNT    LAMA,PHIA,MI,OEIGS $
104  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
105  OFP       LAMA,OEIGS,,,,//V,N,CARDNO $
106  SAVE      CARDNO $
107  COND      FINIS,NEIGV $
108  SDR1      USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,QG/C,N,1/C,N,REIG $
109  CHKPNT    PHIG,QG $
110  PARAM     //C,N,MPY/V,N,SIXSIL/V,N,NSIL/C,N,6 $
111  PARAM     //C,N,EQ /V,N,SCALAR/V,N,SIXSIL/V,N,LUSET $
112  EQUIV     SIL,SIP/SCALAR/BGPDOT,BGPDOP/SCALAR $
113  CHKPNT    SIP,BGPDOP $
114  COND      LBL7,SCALAR $
115  PLTTRAN   BGPDOT,SIL/BGPDOP,SIP/V,N,LUSET/V,N,LUSEP $
116  SAVE      LUSEP $
117  CHKPNT    BGPDOP,SIP $
118  LABEL     LBL7 $
119  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDOP,LAMA,QG,PHIG,EST,,/ ,
              OQG1,OPHIG,OES1,OEFL,PPHIG/C,N,REIG $
120  OFP       OPHIG,OQG1,OEFL,OES1,,//V,N,CARDNO $
121  SAVE      CARDNO $
122  COND      P2,JUMPPLOT $
123  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDOT,EQEXIN,SIP,,PPHIG,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 3

 N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

124	SAVE	PFILE \$
125	PRTMSG	PLOTX2// \$
126	LABEL	P2 \$
127	JUMP	FINIS \$
128	LABEL	ERROR1 \$
129	PRTPARM	//C,N,-1/C,N,MODES \$
130	LABEL	ERROR2 \$
131	PRTPARM	//C,N,-2/C,N,MODES \$
132	LABEL	ERROR3 \$
133	PRTPARM	//C,N,-3/C,N,MODES \$
134	LABEL	FINIS \$
135	END	\$

NORMAL MODE ANALYSIS

3.4.2 Description of DMAP Operations for Normal Mode Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
6. GP2 generates Element Connection Table with internal indices.
10. Go to DMAP No. 20 if no plot package is present.
11. PLTSET transforms user input into a form used to drive structure plotter.
13. PRTMSG prints error messages associated with structure plotter.
16. Go to DMAP No. 20 if no undeformed structure plot request.
17. PLØT generates all requested undeformed structure plots.
19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
22. GP3 generates Grid Point Temperature Table.
24. TAl generates element tables for use in matrix assembly and stress recovery.
26. Go to DMAP No. 128 and print error message if there are no structural elements.
31. EMG generates structural element matrix tables and dictionaries for later assembly.
34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.
35. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
38. Go to DMAP No. 128 and print error message if no mass matrix exists.
39. EMA assembles mass matrix $[M_{gg}]$.
41. Go to DMAP No. 44 if no weight and balance request.
42. GPWG generates weight and balance information.
43. ØFP formats weight and balance information and places it on the system output file for printing.
45. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
47. Go to DMAP No. 50 if no general elements.
48. SMA3 adds general elements to stiffness matrix $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
52. GP4 generates flags defining numbers of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = 0$.
54. Go to DMAP No. 132 and print error message if no independent degrees of freedom are defined.
57. Go to DMAP No. 62 if general elements present.
58. GPSP determines if possible grid point singularities remain.
60. Go to DMAP No. 62 if no Grid Point Singularity Table.
61. ØFP formats table of possible grid point singularities and places it on the system output file for printing.

RIGID FORMATS

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.
65. Go to DMAP No. 70 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \ R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array} \right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.
73. Go to DMAP No. 76 if no single-point constraints.
74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array} \right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array} \right]$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.
78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.
80. Go to DMAP No. 85 if no omitted coordinates.
81. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

NORMAL MODE ANALYSIS

83. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

86. Go to DMAP No. 95 if no free-body supports.

87. RBMG1 partitions out free-body supports

$$[K_{aa}] = \begin{bmatrix} K_{\ell\ell} & K_{\ell r} \\ K_{r\ell} & K_{rr} \end{bmatrix} \quad \text{and} \quad [M_{aa}] = \begin{bmatrix} M_{\ell\ell} & M_{\ell r} \\ M_{r\ell} & M_{rr} \end{bmatrix}.$$

89. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

91. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}.$$

93. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

96. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

98 Go to DMAP No. 130 and print error message if no Eigenvalue Extraction Data.

101. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized, computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D \phi_{ro} \\ \phi_{ro} \end{bmatrix},$$

RIGID FORMATS

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

- 1) Unit value of selected coordinate
- 2) Unit value of largest component
- 3) Unit value of generalized mass.

105. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.
107. Go to DMAP No. 134 and exit if no eigenvalues found.
108. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} , \quad \begin{pmatrix} \phi_a \\ \phi_o \end{pmatrix} = \{\phi_f\} ,$$

$$\begin{pmatrix} \phi_f \\ \phi_s \end{pmatrix} = \{\phi_n\} , \quad \{\phi_m\} = [G_m]\{\phi_n\} ,$$

$$\begin{pmatrix} \phi_n \\ \phi_m \end{pmatrix} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}]^T \{\phi_f\}$.

112. Equivalence SIL to SIP and BGPDT to BGPD when one or more geometric grid points exist.
114. Go to DMAP No. 118 if
115. PLTRAN modifies BGPD and SIL for functional modules SDR2 and PLØT.
119. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares eigenvectors and single-point forces of constraint for output (ØPHIG, PPHIG, ØQG1).
120. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.
122. Go to DMAP No. 126 if no deformed structure plots are requested.
123. PLØT generates all requested deformed structure plots.
125. PRTMSG prints plotter data and engineering data for each deformed plot generated.
127. Go to DMAP No. 134 and make normal exit.

NORMAL MODE ANALYSIS

- 129. NORMAL MODE ANALYSIS ERROR MESSAGE NO. 1 - MASS MATRIX REQUIRED FOR REAL EIGENVALUE ANALYSIS.
- 131. NORMAL MODE ANALYSIS ERROR MESSAGE NO. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.
- 133. NORMAL MODE ANALYSIS ERROR MESSAGE NO. 3 - NO INDEPENDENT DEGREES OF FREEDOM HAVE BEEN DEFINED.

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3.4.3 Automatic Output for Normal Mode Analysis

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
 - (1) Two consecutive singularities encountered while performing triangular decomposition.
 - (2) Four shift points while tracking a single root.
 - (3) All eigenvalues found in the frequency range specified.
 - (4) Three times the number of roots estimated in the frequency range have been extracted.
 - (5) All eigenvalues that exist in the problem have been found.
 - (6) The number of roots desired have been found.
 - (7) One or more eigenvalues have been found outside the frequency range specified.
 - (8) Insufficient time to find another root.
 - (9) Unable to converge
7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

NORMAL MODE ANALYSIS

1. Number of eigenvalues extracted.
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Reason for termination.
 - (1) The number of roots desired have been found.
 - (2) All predictions for eigenvalues are outside the frequency range specified.
 - (3) Insufficient time to find another root.
 - (4) Matrix is singular at first three starting points.
8. Largest off-diagonal modal mass term and the number failing the criterion.
9. Swept determinant function for each starting point.

The following summary of the eigenvalue analysis performed using the Givens method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of eigenvectors computed.
3. Number of eigenvalue convergence failures.
4. Number of eigenvector convergence failures.
5. Reason for termination.
 - (1) Normal termination.
 - (2) Insufficient time to calculate eigenvalues and number of eigenvectors requested.
 - (3) Insufficient time to find additional eigenvectors.
6. Largest off-diagonal modal mass term and the number failing the criterion.

3.4.4 Case Control Deck and Parameters for Normal Mode Analysis

The following items relate to subcase definition and data selection for Normal Modes:

1. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.
2. On restart, the current EIGR card controls the eigenvalue extraction, regardless of what calculations were made in the previous execution. Consequently, when making restarts with either the Determinant method or the Inverse Power method, METHØD should be changed

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to select an EIGR card that avoids the extraction of previously found eigenvalues. This is particularly important following unscheduled exits due to insufficient time to find all eigenvalues in the range of interest.

3. An SPC set must be selected unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. Multiple subcases are used only to control output requests. A single subcase is sufficient if the same output is desired for all modes. If multiple subcases are present, the output requests will be honored in succession for increasing mode numbers. M0DES may be used to repeat subcases in order to make the same output request for several consecutive modes.

The following output may be requested for Normal Mode Analysis:

1. Eigenvectors along with the associated eigenvalue for each mode.
2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.
3. Forces and stresses in selected elements for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected modes.

The following parameters are used in Normal Mode Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.
3. C0UPMASS - CPBAR, CPR0D, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

NORMAL MODE ANALYSIS

3.4.5 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Normal Modes Analysis, Rigid Format 3, are altered in automatic substructure analyses.

Phase 1: 53, 86-95, 96-126

Phase 2: 3-4, 10-21, 26, 38, 45-48, 57-62, 119-126

Phase 3: 86-95, 100-107, 108

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

3.5 STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

3.5.1 DMAP Sequence for Static Analysis with Differential Stiffness

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 4

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

1	BEGIN	NO.4 DIFFERENTIAL STIFFNESS ANALYSIS - SERIES N \$
2	GP1	GEOM1,GEOM2,/GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL/V,N,LUSET/ V,N, NOGPD,T \$
3	SAVE	LUSET,NOGPD,T \$
4	COND	ERROR1,NOGPD,T \$
5	CHKPNT	GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL \$
6	GP2	GEOM2,EQEXIN/ECT \$
7	CHKPNT	ECT \$
8	PARAML	PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB \$
9	PURGE	PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB \$
10	CUND	P1,NOPCDB \$
11	PLTSET	PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N, JUMPPLOT=-1 \$
12	SAVE	NSIL,JUMPPLOT \$
13	PRTMSG	PLTSETX// \$
14	PARAM	//C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 \$
15	PARAM	//C,N,MPY/V,N,PFILE/C,N,0/C,N,0 \$
16	CUND	P1,JUMPPLOT \$
17	PLOT	PLTPAR,GPSETS,ELSETS,CASECC,BGPD,T,EQEXIN,SIL,,,/PLOTX1/ V,N, NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
18	SAVE	JUMPPLOT,PLTFLG,PFILE \$
19	PRTMSG	PLOTX1// \$
20	LABEL	P1 \$
21	CHKPNT	PLTPAR,GPSETS,ELSETS \$
22	GP3	GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV \$
23	SAVE	NOGRAV \$
24	PARAM	//C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 \$
25	CHKPNT	SLT,GPTT \$
26	TAL	ECT,EPT,BGPD,T,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N,

RIGID FORMATS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION

NO.		
		NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL \$
27	SAVE	NOSIMP,NOGENL,GENEL \$
28	COND	ERROR1,NOSIMP \$
29	PURGE	OGPST/GENEL \$
30	CHKPNT	EST,GPECT,GE1,OGPST \$
31	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
32	EMG	EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V, N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
33	SAVE	NOKGGX,NOMGG \$
34	CHKPNT	KELM,KDICT,MELM,MDICT \$
35	COND	JMPKGG,NOKGGX \$
36	EMA	GPECT,KDICT,KELM/KGGX,GPST \$
37	CHKPNT	KGGX,GPST \$
38	LABEL	JMPKGG \$
39	COND	JMPMGG,NOMGG \$
40	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
41	CHKPNT	MGG \$
42	LABEL	JMPMGG \$
43	COND	LBL1,GRDPNT \$
44	COND	ERROR4,NOMGG \$
45	GPWG	BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS \$
46	DFP	OGPWG,,,,// \$
47	LABEL	LBL1 \$
48	EQUIV	KGGX,KGG/NOGENL \$
49	CHKPNT	KGG \$
50	COND	LBL11,NOGENL \$
51	SMA3	GE1,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$
52	CHKPNT	KGG \$

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 4

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

53	LABEL	LBL11 \$
54	PARAM	//C,N,MPY/V,N,NSKIP/C,N,O/C,N,O \$
55	GP4	CASECC,GEOM4,EQEXIN,SIL,GPD,T,BGPD,T,CSTM/RG,YS,USET,ASET/V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
56	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA \$
57	COND	ERROR5,NOL \$
58	PURGE	GM/MPCF1/GO,KGO,LGO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS,QG/SINGLE/ UBOOV/OMIT/YBS,PBS,KBFS,KBSS,KDFS,KDSS/SINGLE \$
59	CHKPNT	GM,RG,GO,KGO,LOG,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET, UBOOV, YBS,PBS,KBFS,KBSS,KDFS,KDSS,QG \$
60	COND	LBL4D,REACT \$
61	JUMP	ERROR2 \$
62	LABEL	LBL4D \$
63	COND	LBL4,GENEL \$
64	GPSP	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
65	SAVE	NOGPST \$
66	COND	LBL4,NOGPST \$
67	DFP	OGPST,,,,,// \$
68	LABEL	LBL4 \$
69	EQUIV	KGG,KNN/MPCF1 \$
70	CHKPNT	KNN \$
71	COND	LBL2,MPCF2 \$
72	MCE1	USET,RG/GM \$
73	CHKPNT	GM \$
74	MCE2	USET,GM,KGG,,,/KNN,,, \$
75	CHKPNT	KNN \$
76	LABEL	LBL2 \$
77	EQUIV	KNN,KFF/SINGLE \$
78	CHKPNT	KFF \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

79	COND	LBL3,SINGLE \$
80	<u>SCE1</u>	USET,KNN,,,/KFF,KFS,KSS,,, \$
81	CHKPNT	KFS,KSS,KFF \$
82	LABEL	LBL3 \$
83	EQUIV	KFF,KAA/OMIT \$
84	CHKPNT	KAA \$
85	COND	LBL5,GMIT \$
86	<u>SMP1</u>	USET,KFF,,,/GO,KAA,KOU,LOO,,,,, \$
87	CHKPNT	GO,KAA,KOU,LOO \$
88	LABEL	LBL5 \$
89	<u>RBMG2</u>	KAA/LLL \$
90	CHKPNT	LLL \$
91	<u>SSG1</u>	SLT,BGPD,CSTM,SIL,EST ,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N, LUSET/C,N,1 \$
92	CHKPNT	PG \$
93	EQUIV	PG,PL/NOSET \$
94	CHKPNT	PL \$
95	COND	LBL10,NOSET \$
96	<u>SSG2</u>	USET,GM,YS,KFS,GO,,PG/,PO,PS,PL \$
97	CHKPNT	PO,PS,PL \$
98	LABEL	LBL10 \$
99	<u>SSG3</u>	LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/ C,N,1/V,N,EPSI \$
100	SAVE	EPSI \$
101	CHKPNT	ULV,UOOV,RULV,RUOV \$
102	COND	LBL9,IRES \$
103	MATGPR	GPL,USET,SIL,RULV//C,N,L \$
104	MATGPR	GPL,USET,SIL,RUCV//C,N,D \$
105	LABEL	LBL9 \$

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

106	SDR1	USET,,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PG1,QG/C,N,1/C,N,DSO \$
107	CHKPNT	UGV,QG \$
108	SDR2	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,ECT,BGPD,.,QG,UGV,EST,,PG/ OPG1,OQG1,OUGV1,OES1,DEF1,PUGV1/C,N,DSO \$
109	PARAM	//C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 \$
110	OFF	OUGV1,OPG1,OQG1,DEF1,OES1,//V,N,CARDNO \$
111	SAVE	CARDNO \$
112	COND	P2,JUMPPLOT \$
113	PLOT	PLTPAR,GPSETS,ELSETS,CASECC,BGPD,.,EQEXIN,SIL,PUGV1,,GPCT,OES1/ PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
114	SAVE	PFILE \$
115	PRTMSG	PLOTX2// \$
116	LABEL	P2 \$
117	TA1	ECT,EPT,BGPD,.,SIL,GPTT,CSTM/X1,X2,ECPT,GPCT/V,N,LUSET/ V,N, NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL \$
118	DSMG1	CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/ V,N, DSCOSET \$
119	CHKPNT	KDGG \$
120	PARAM	//C,N,ADD/V,N,SHIFT/C,N,-1/C,N,0 \$
121	PARAM	//C,N,ADD/V,N,COUNT/V,N,ALWAYS=-1/V,N,NEVER= 1 \$
122	PARAMR	//C,N,ADD/V,N,DSEPSI/C,N,0.0/C,N,0.0 \$
123	PARAML	YS//C,N,NULL/C,N,/C,N,/C,N,/V,N,NOYS \$
124	JUMP	OUTLPTOP \$
125	LABEL	OUTLPTOP \$
126	EQUIV	PG,PG1/NOYS \$
127	CHKPNT	PG1 \$
128	PARAM	//C,N,KLOCK/V,N,TO \$
129	EQUIV	KDGG,KDNN/MPCF2 \$
130	CHKPNT	KDNN \$
131	COND	LBL2D,MPCF2 \$

Top of Stiffness
Adjustment Loop

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 4

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

132	MCE2	USET,GM,KDGG,,,/KDNN,,, \$
133	CHKPNT	KDNN \$
134	LABEL	LBL2D \$
135	EQUIV	KDNN,KOFF/SINGLE \$
136	CHKPNT	KOFF \$
137	COND	LBL3D,SINGLE \$
138	SCE1	USET,KDNN,,,/KOFF,KDFS,KDSS,,, \$
139	CHKPNT	KOFF,KDFS,KDSS \$
140	LABEL	LBL3D \$
141	EQUIV	KOFF,KDAA/OMIT \$
142	CHKPNT	KDAA \$
143	COND	LBL5D,OMIT \$
144	SMP2	USET,GO,KOFF/KDAA \$
145	CHKPNT	KDAA \$
146	LABEL	LBL5D \$
147	ADD	KAA,KDAA/KBLL \$
148	ADD	KFS,KDFS/KBFS \$
149	ADD	KSS,KDSS/KBSS \$
150	COND	PGOK,NOYS \$
151	MPYAD	KBSS,YS,/PSS/C,N,0/C,N,1/C,N,1/C,N,1 \$
152	MPYAD	KBFS,YS,/PFS/C,N,0/C,N,1/C,N,1/C,N,1 \$
153	UMERGE	USET,PFS,PSS/PN/C,N,N/C,N,F/C,N,S \$
154	EQUIV	PN,PGX/MPCF2 \$
155	COND	LBL6D,MPCF2 \$
156	UMERGE	USET,PN,/PGX/C,N,G/C,N,N/C,N,M \$
157	LABEL	LBL6D \$
158	ADD	PGX,PG/PGG/C,N,(-1.0,0.0) \$
159	EQUIV	PGG,PG1/ALWAYS \$

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 4

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

160	LABEL	PGOK \$	
161	ADD	PG1,/PGO/ \$	
162	REMG2	KBLL/LBLL/V,N,POWER/V,N,DET \$	
163	SAVE	DET,POWER \$	
164	CHKPNT	LBLL \$	
165	PRTPARM	//C,N,O/C,N,DET \$	
166	PRTPARM	//C,N,O/C,N,POWER \$	
167	JUMP	INLPTOP \$	
168	LABEL	INLPTOP \$	Top of Load Correction Loop
169	PARAM	//C,N,KLOCK/V,N,TI \$	
170	SSG2	USET,GM,YS,KDFS,GO,,PG1/,PBO,PBS,PBL \$	
171	SSG3	LBLL,KBLL,PBL,,,/UBLV,,RUBLV,/C,N,-1/V,Y,IRES/V,N,NDSKIP/V,N, EPSI \$	
172	SAVE	EPSI \$	
173	CHKPNT	UBLV,RUBLV \$	
174	COND	LBL9D,IRES \$	
175	MATGPR	GPL,USET,SIL,RUBLV//C,N,L \$	
176	LABEL	LBL9D \$	
177	SDR1	USET,,UBLV,,YS,GO,GM,PBS,KBFS,KBSS,/UBGV,,QBG/C,N,1/C,N,DS1 \$	
178	CHKPNT	UBGV,QBG \$	
179	ADD	UBGV,UGV/DUGV/C,N,(-1.0,0.0) \$	
180	DSMG1	CASECC,GPTT,SIL,EDT,DUGV,CSTM,MPT,ECPT,GPCT,DIT/DKDGG/V,N, DSC0SET \$	
181	CHKPNT	DKDGG \$	
182	MPYAD	CKDGG,UBGV,PGO/PGI1/C,N,O/C,N,1/C,N,1/C,N,1 \$	
183	DSCHK	PG1,PGI1,UBGV//C,Y,EPSI0=1.E-5/V,N,DSEPSI/C,Y,NT=10/V,N,TD/V,N, TI/V,N,DONE/V,N,SHIFT/V,N,COUNT/C,Y,BETA0=4 \$	
184	SAVE	DSEPSI,DONE,SHIFT,COUNT \$	
185	COND	DONE,DONE \$	
186	COND	SHIFT,SHIFT \$	

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 4

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

187	EQUIV	PG,PG1/NEVER \$	
188	EQUIV	PGI1,PG1/ALWAYS \$	
189	EQUIV	PG1,PGI1/NEVER \$	
190	REPT	INLPTOP,1000 \$	
191	TABPT	PGI1,PG1,PG, ,// \$	Bottom of Load Correction Loop
192	LABEL	SHIFT \$	
193	ADD	DKDGG,KDGG/KDGG1/C,N,(-1.0,0.0) \$	
194	CHKPNT	KDGG1 \$	
195	EQUIV	UBGV,UGV/ALWAYS/KDGG1,KDGG/ALWAYS \$	
196	CHKPNT	KDGG \$	
197	EQUIV	KDGG,KDGG1/NEVER/UGV,UBGV/NEVER \$	
198	REPT	OUTLPTOP,1000 \$	
199	TABPT	KDGG1,KDGG,UGV, ,// \$	Bottom of Stiffness Adjustment Loop
200	LABEL	DONE \$	
201	CHKPNT	CSTM \$	
202	SDR2	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QBG,UBGV,EST, ,/ ,QDBG1,OUBGV1,OESB1,DEFB1,PUBGV1/C,N,DS1 \$	
203	OFF	OUBGV1,QDBG1,DEFB1,OESB1, ,//V,N,CARDNO \$	
204	SAVE	CARDNO \$	
205	COND	P3,JUMPPLOT \$	
206	PLOT	PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUBGV1, ,GPECT, OESB1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N, PFILE \$	
207	SAVE	PFILE \$	
208	PRTMSG	PLOTX3// \$	
209	LABEL	P3 \$	
210	JUMP	FINIS \$	
211	LABEL	ERRGR1 \$	
212	PRTPARM	//C,N,-1/C,N,DIFFSTIF \$	
213	LABEL	ERROR2 \$	

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 4

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

214 PRTPARM //C,N,-2/C,N,DIFFSTIF \$
215 LABEL ERRCR4 \$
216 PRTPARM //C,N,-4/C,N,DIFFSTIF \$
217 LABEL ERROR5 \$
218 PRTPARM //C,N,-5/C,N,DIFFSTIF \$
219 LABEL FINIS \$
220 END \$

RIGID FORMATS

3.5.2 Description of DMAP Operations for Static Analysis with Differential Stiffness

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
4. Go to DMAP No. 211 if no grid point definition table.
6. GP2 generates Element Connection Table with internal indices.
10. Go to DMAP No. 20 if no plot package is present.
11. PLTSET transforms user input into a form used to drive structure plotter.
13. PRTMSG prints error messages associated with structure plotter.
16. Go to DMAP No. 20 if no undeformed structure plot request.
17. PLØT generates all requested undeformed structure plots.
19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
22. GP3 generates Static Loads Table and Grid Point Temperature Table.
26. TAI generates element tables for use in matrix assembly and stress recovery.
28. Go to DMAP No. 211 and print error message if no structural elements
32. EMG generates structural element matrix tables and dictionaries for later assembly.
35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.
36. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
39. Go to DMAP No. 42 if no mass matrix is to be assembled.
40. EMA assembles mass matrix $[M_{gg}]$.
43. Go to DMAP No. 47 if no weight and balance request.
44. Go to DMAP No. 215 and print error message if no mass matrix exists.
45. GPWG generates weight and balance information.
46. ØFP formats weight and balance information and places it on the system output file for printing.
48. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
50. Go to DMAP No. 53 if no general elements.
51. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
55. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.
57. Go to DMAP No. 217 and print error message if no independent degrees of freedom are defined.
60. Go to DMAP No. 62 if no free-body supports supplied.
63. Go to DMAP No. 68 if general elements present.
64. GPSP determines if possible grid point singularities remain.

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

66. Go to DMAP No. 68 if no Grid Point Singularity Table.
67. ØFP formats table of possible grid point singularities and places it on the system output file for printing.
69. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.
71. Go to DMAP No. 76 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
72. MCE1 partitions multipoint constraint equations $[R_g] = [R_m; R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
74. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

77. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.
79. Go to DMAP No. 82 if no single-point constraints.
80. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array} \right]$$

83. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.
85. Go to DMAP No. 88 if no omitted coordinates.
86. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

89. RMBG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$
91. SSG1 generates static load vectors $\{P_g\}$.
93. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.
95. Go to DMAP No. 98 if no constraints applied.

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96. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ P_m \end{Bmatrix}, \quad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ P_s \end{Bmatrix}, \quad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{P_s\},$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ P_o \end{Bmatrix} \quad \text{and} \quad \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\}.$$

99. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{aa}]^{-1}\{P_\ell\},$$

solves for displacements of omitted coordinates

$$\{u_o^0\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{aa}]\{u_\ell\}$$

$$\epsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^0\},$$

$$\epsilon_o = \frac{\{u_o^{0T}\}\{\delta P_o\}}{\{P_o^T\}\{u_o^0\}}.$$

102. Go to DMAP No. 105 if residual vectors are not to be printed.

103. Print residual vector for independent coordinates (RULV).

104. Print residual vector for omitted coordinates (RUØV).

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

106. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\lambda\} + \{u_o^0\} ,$$

$$\begin{Bmatrix} u_a \\ u_o \end{Bmatrix} = \{u_f\} , \quad \begin{Bmatrix} u_f \\ y_s \end{Bmatrix} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\}, \quad \begin{Bmatrix} u_n \\ u_m \end{Bmatrix} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{y_s\} .$$

108. SDR2 calculates element forces and stresses ($\emptyset EF1$, $\emptyset ES1$) and prepares load vectors, displacement vectors and single-point forces of constraint for output ($\emptyset PG1$, $\emptyset UGV1$, $PUGV1$, $\emptyset QG1$).

110. $\emptyset FP$ formats tables prepared by SDR2 and places them on the system output file for printing.

112. Go to DMAP No. 116 if no static deformed structure plots are requested.

113. $PL\emptyset T$ generates all requested static deformed structure plots.

115. $PRTMSG$ prints plotter data and engineering data for each deformed plot generated.

117. $TA1$ generates element tables for use in differential stiffness matrix assembly.

118. $DSMG1$ generates differential stiffness matrix $[K_{gg}^d]$.

124. Go to next DMAP instruction if cold start or modified restart. $\emptyset UTLPT\emptyset P$ will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

125. Beginning of outer loop for differential stiffness iteration.

126. Equivalence $\{P_g\}$ to $\{P_{g1}\}$ if no enforced displacements.

129. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.

131. Go to DMAP No. 134 if no multipoint constraints.

132. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \begin{bmatrix} \bar{K}_{nn}^d & K_{nm}^d \\ K_{mn}^d & K_{mm}^d \end{bmatrix}$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

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135. Equivalence $[K_{nn}^d]$ to $[K_{ff}^d]$ if no single-point constraints.

137. Go to DMAP No. 140 if no single-point constraints.

138. SCE1 partitions out single-point constraints

$$[K_{nn}^d] = \left[\begin{array}{c|c} K_{ff}^d & K_{fs}^d \\ \hline K_{sf}^d & K_{ss}^d \end{array} \right]$$

141. Equivalence $[K_{ff}^d]$ to $[K_{aa}^d]$ if no omitted coordinates.

143. Go to DMAP No. 146 if no omitted coordinates.

144. SMP2 partitions constrained differential stiffness matrix

$$[K_{ff}^d] = \left[\begin{array}{c|c} \bar{K}_{aa}^d & K_{ao}^d \\ \hline K_{oa}^d & K_{oo}^d \end{array} \right]$$

and performs matrix reduction $[K_{aa}^d] = [\bar{K}_{aa}^d] + [K_{oa}^d]^T [G_o] + [G_o]^T [K_{oa}^d] + [G_o]^T [K_{oo}^d] [G_o]$.

147. ADD $[K_{aa}]$ and $[K_{aa}^d]$ to form $[K_{\ell\ell}^b]$.

148. ADD $[K_{fs}]$ and $[K_{fs}^d]$ to form $[K_{fs}^b]$.

149. ADD $[K_{ss}]$ and $[K_{ss}^d]$ to form $[K_{ss}^b]$.

150. Go to DMAP No. 160 if no enforced displacements.

151. MPYAD multiply $[K_{ss}^b]$ and $\{Y_s\}$ to form $\{P_{ss}\}$.

152. MPYAD multiply $[K_{fs}^b]$ and $\{Y_s\}$ to form $\{P_{fs}\}$.

153. UMERGE expand $\{P_n\}$ to form $\{P_g^x\}$.

158. ADD $-\{P_g^x\}$ and $\{P_g\}$ to form $\{P_{gg}\}$.

159. Equivalence $\{P_{gg}\}$ to $\{P_{g1}\}$.

161. ADD $\{P_{g1}\}$ and nothing to create $\{P_{go}\}$.

162. RBMG2 decomposes the combined differential stiffness matrix and elastic stiffness matrix.

$$[K_{\ell\ell}^b] = [L_{\ell\ell}^b][U_{\ell\ell}^b]$$

165. PRTPARM prints the scaled value of the determinant of the combined differential stiffness matrix and elastic stiffness matrix.

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

166. PRTPARM prints the scale factor (power of ten) of the determinant of the combined differential stiffness matrix and the elastic stiffness matrix.
167. Go to next DMAP instruction if cold start or modified restart. INLPTØP will be altered by the executive system to the proper location inside the loop for unmodified restarts within the loop.
168. Beginning of inner loop for differential stiffness iteration.
170. SSG2 applies constraints to static load vectors

$$\begin{aligned} \{P_{gl}\} &= \begin{pmatrix} \bar{p}_n^b \\ \bar{p}_m^b \end{pmatrix}, & \{P_n^b\} &= \{\bar{p}_n^b\} + [G_m^T] \{P_m^b\}, \\ \{P_n^b\} &= \begin{pmatrix} \bar{p}_f^b \\ \bar{p}_s^b \end{pmatrix}, & \{P_f^b\} &= \{\bar{p}_f^b\} - [K_{fs}^d] \{Y_s\}, \\ \{P_f^b\} &= \begin{pmatrix} p_a^b \\ p_o^b \end{pmatrix} & \text{and} & \{P_\ell^b\} = \{P_a^b\} + [G_o^T] \{P_o^b\}. \end{aligned}$$

171. SSG3 solves for displacements of independent coordinates for current differential stiffness load vector

$$\{u_\ell^b\} = [K_{\ell\ell}^b]^{-1} \{P_\ell^b\}$$

and calculates residual vector (RBULV) and residual vector error ratio for current differential stiffness load vector

$$\begin{aligned} \{\delta P_\ell^b\} &= \{P_\ell^b\} - [K_{\ell\ell}^b] \{u_\ell^b\}, \\ \epsilon_\ell^b &= \frac{\{u_\ell^b\}^T \{\delta P_\ell^b\}}{\{P_\ell^b\}^T \{u_\ell^b\}}. \end{aligned}$$

174. Go to DMAP No. 176 if residual vector for current differential stiffness solution is not to be printed.
175. Print residual vector for current differential stiffness solution.

RIGID FORMATS

177. SDRI recovers dependent displacements for current differential stiffness solution

$$\{u_o^b\} = [G_o]\{u_\ell^b\} + \{u_o^{ob}\} , \quad \begin{pmatrix} u_\ell^b \\ u_o^b \end{pmatrix} = \{u_f^b\} ,$$

$$\begin{pmatrix} u_f^b \\ \gamma_s^b \end{pmatrix} = \{u_n^b\} , \quad \{u_m^b\} = [G_m]\{u_n^b\} ,$$

$$\begin{pmatrix} u_n^b \\ u_m^b \end{pmatrix} = \{u_g^b\}$$

and recovers single-point forces of constraint for current differential stiffness solution

$$\{q_s^b\} = -\{P_s^b\} + [K_{sf}^b]\{u_f^b\} + [K_{ff}^b]\{\gamma_s^b\} .$$

179. ADD $-\{u_g^b\}$ and $\{U_g\}$ to form $\{U_g^d\}$.

180. DSMG1 generates differential stiffness matrix $[\delta K_{gg}^d]$

182. MPYAD form load vector for inner loop iteration.

$$\{P_{g11}\} = [\delta K_{gg}^d]\{U_g^b\} + \{P_{go}\}$$

183. DSCHK performs differential stiffness convergence checks.

185. Go to DMAP No. 200 if differential stiffness iteration is complete.

186. Go to DMAP No. 192 if additional differential stiffness matrix changes are necessary for further iteration.

187. Equivalence breaks previous equivalence of $\{P_g\}$ to $\{P_{g1}\}$.

188. Equivalence $\{P_{g11}\}$ to $\{P_{g1}\}$

189. Equivalence breaks previous equivalence of $\{P_{g1}\}$ to $\{P_{g11}\}$.

190. Go to DMAP No. 168 for additional inner loop differential stiffness iteration.

191. TABPT table prints vectors $\{P_{g11}\}$, $\{P_{g1}\}$, and $\{P_g\}$.

193. ADD $-\{K_{gg}^d\}$ and $[K_{gg}^d]$ to form $[K_{gg1}^d]$.

195. Equivalence $\{U_g^b\}$ to $\{U_g\}$ and $[K_{gg1}^d]$ to $[K_{gg}^d]$.

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

197. Equivalence breaks previous equivalence of $[K_{gg}^d]$ to $[K_{gg1}^d]$ and $\{U_g\}$ to $\{U_g^b\}$.
198. Go to DMAP No. 125 for additional outer loop differential stiffness iteration.
199. TABPT table prints $[K_{gg1}^d]$, $[K_{gg}^d]$ and $\{U_g\}$.
202. SDR2 calculates element forces and stresses ($\emptyset EFB1$, $\emptyset ESB1$) and prepares displacement vectors and single-point forces of constraint for output ($\emptyset UBGV1$, $PIJBGV1$, $\emptyset OBG1$) for all differential stiffness solutions.
203. $\emptyset FP$ formats tables prepared by SDR2 and places them on the system output file for printing.
205. Go to DMAP No. 209 if no deformed differential stiffness structure plots are requested.
206. $PL\emptyset T$ generates all requested deformed differential stiffness structure plots.
208. $PRTMSG$ prints plotter data and engineering data for each deformed plot generated.
210. Go to DMAP No. 219 and make normal exit.
212. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERROR MESSAGE NO. 1 - NO STRUCTURAL ELEMENTS HAVE BEEN DEFINED.
214. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERROR MESSAGE NO. 2 - FREE BODY-SUPPORTS NOT ALLOWED.
216. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERROR MESSAGE NO. 4 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.
218. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERROR MESSAGE NO. 5 - NO INDEPENDENT DEGREES OF FREEDOM HAVE BEEN DEFINED.

RIGID FORMATS

3.5.3 Automatic Output for Static Analysis with Differential Stiffness

The value of the determinant of the sum of the elastic stiffness and the differential stiffness is automatically printed for each differential stiffness loading condition.

Iterative differential stiffness computations are terminated for one of five reasons. Iteration termination reasons are automatically printed in an information message. These reasons have the following meanings:

1. REASON 0 means the iteration procedure was incomplete at the time of exit. This is caused by an unexpected interruption of the iteration procedure prior to the time the subroutine has had a chance to perform necessary checks and tests. Not much more has happened other than to initialize the exit mode to REASON 0.
2. REASON 1 means the iteration procedure converged to the EPSIØ value supplied by the user on a PARAM bulk data card. (The default value of EPSIØ is 1.0E-5.)
3. REASON 2 means iteration procedure is diverging from the EPSIØ value supplied by the user on a PARAM bulk data card. (The default value of EPSIØ is 1.0E-5.)
4. REASON 3 means insufficient time remaining to achieve convergence to the EPSIØ value supplied by the user on a PARAM bulk data card. (The default value of EPSIØ is 1.0E-5.)
5. REASON 4 means the number of iterations supplied by the user on a PARAM bulk data card, has been met. (The default number of iterations is 10.)

Parameter values at the time of exit are automatically output as follows:

1. Parameter DØNE: -1 is normal; + N is the estimate of the number of iterations required to achieve convergence.
2. Parameter SHIFT: +1 indicates a return to the top of the inner loop was scheduled; -1 indicates a return to top of the outer loop was scheduled following the current iteration.
3. Parameter DSEPSI: the value of the ratio of energy error to total energy at the time of exit.

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

3.5.4 Case Control Deck and Parameters for Static Analysis with Differential Stiffness

The following items relate to subcase definition and data selection for Static Analysis with Differential Stiffness:

1. The Case Control Deck must contain at least two subcases. Other than DSCOEFFICIENT in the second subcase, all subcases are used only for output selection.
2. DSCOEFFICIENT must appear in the second subcase, either to select a DSFACT set from the Bulk Data Deck, or to explicitly select the default value of unity.
3. A static loading condition must be defined above the subcase level with a LOAD, TEMPERATURE(LOAD), or DEFORM selection, unless all loading is specified by grid point displacements on SPC cards.
4. An SPC set must be selected above the subcase level unless all constraints are specified on GRID cards.
5. Output requests that apply only to the linear solution must appear in the first subcase.
6. Output requests that apply only to the solution with differential stiffness must be placed in the second and succeeding subcases. If only two subcases exist, the output requests in the second subcase will be honored for all differential stiffness loading conditions.
7. Output requests that apply to all solutions, both with and without differential stiffness may be placed above the subcase level.

The following output may be requested for Static Analysis with Differential Stiffness:

1. Nonzero Components of the applied static load for the linear solution at selected grid points.
2. Displacement and nonzero components of the single-point forces of constraint, with and without differential stiffness, at selected grid points.
3. Forces and stresses in selected elements, with and without differential stiffness.
4. Undeformed and deformed plots of the structural model.

The following parameters are used in Static Analysis with Differential Stiffness:

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1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMG.
3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.
4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
5. BETAD - optional - the integer value of this parameter is the assumed number of iterations for the inner loop in shift decisions for iterated differential stiffness. The default value is 4 iterations.
6. NT - optional - the integer value of this parameter limits the maximum number of iterations. The default value is 10 iterations.
7. EPSIØ - optional - the real value of this parameter is used to test the convergence of iterated differential stiffness. The default value is 10^{-5} .

BUCKLING ANALYSIS

3.6 BUCKLING ANALYSIS

3.6.1 DMAP Sequence for Buckling Analysis

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NO.5 BUCKLING ANALYSIS - SERIES N $
2 FILE       LAMA=APPEND/PHIA=APPEND $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
              NOGPDT $
4 SAVE       LUSET $
5 CHKPNT     GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
6 GP2        GEOM2,EQEXIN/ECT $
7 CHKPNT     ECT $
8 PARAML     PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
9 PURGE      PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
10 COND      P1,NOPCDB $
11 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
              JUMPPLOT=-1 $
12 SAVE      NSIL,JUMPPLOT $
13 PRMSG     PLTSETX// $
14 PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
15 PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
16 COND      P1,JUMPPLOT $
17 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,/PLOTX1/  V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
18 SAVE      JUMPPLOT,PLTFLG,PFILE $
19 PRMSG     PLOTX1// $
20 LABEL     P1 $
21 CHKPNT     PLTPAR,GPSETS,ELSETS $
22 GP3        GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $
23 SAVE      NOGRAV $
24 PARAM     //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $

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RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 5

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

25	CHKPNT	SLT,GPTT \$
26	TAI	ECT,EPT,BGPD,T,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N, NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL \$
27	SAVE	NOSIMP,NOGENL,GENEL \$
28	COND	ERROR1,NOSIMP \$
29	PURGE	OGPST/GENEL \$
30	CHKPNT	EST,GPECT,GEI,OGPST \$
31	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
32	EMG	EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V, N,NOMGG/C,N,/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
33	SAVE	NOKGGX,NOMGG \$
34	CHKPNT	KELM,KDICT,MELM,MDICT \$
35	COND	JMPKGG,NOKGGX \$
36	EMA	GPECT,KDICT,KELM/KGGX,GPST \$
37	CHKPNT	KGGX,GPST \$
38	LABEL	JMPKGG \$
39	COND	JMPMGG,NOMGG \$
40	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
41	CHKPNT	MGG \$
42	LABEL	JMPMGG \$
43	COND	LBL1,GRDPNT \$
44	COND	ERROR5,NOMGG \$
45	GPWG	BGPD,T,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS. \$
46	OFF	OGPWG,,,,,// \$
47	LABEL	LBL1 \$
48	EQUIV	KGGX,KGG/NOGENL \$

BUCKLING ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

49	CHKPNT	KGG \$
50	COND	LBL11,NOGENL \$
51	<u>SMA3</u>	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$
52	CHKPNT	KGG \$
53	LABEL	LBL11 \$
54	PARAM	//C,N,MPY/V,N,NSKIP/C,N,O/C,N,O \$
55	<u>GP4</u>	CASECC,GEOM4,EQEXIN,SIL,GPD,T,BGPD,T,CSTM/RG,YS,USET,ASET/V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
56	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA \$
57	COND	ERROR6,NOL \$
58	PARAM	//C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT \$
59	PURGE	GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS/SINGLE/ QG/ NOSR \$
60	CHKPNT	GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,QG \$
61	COND	LBL4D,REACT \$
62	JUMP	ERROR2 \$
63	LABEL	LBL4D \$
64	COND	LBL4,GENEL \$
65	<u>GPSP</u>	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
66	SAVE	NOGPST \$
67	COND	LBL4,NOGPST \$
68	<u>QFP</u>	OGPST,,,,,// \$
69	LABEL	LBL4 \$
70	EQUIV	KGG,KNN/MPCF1 \$
71	CHKPNT	KNN \$
72	COND	LBL2,MPCF2 \$
73	<u>MCE1</u>	USET,RG/GM \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 5

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

74	CHKPNT	GM \$
75	<u>MCE2</u>	USET,GM,KGG,,,/KNN,,, \$
76	CHKPNT	KNN \$
77	LABEL	LBL2 \$
78	EQUIV	KNN,KFF/SINGLE \$
79	CHKPNT	KFF \$
80	COND	LBL3,SINGLE \$
81	<u>SCE1</u>	USET,KNN,,,/KFF,KFS,KSS,,, \$
82	CHKPNT	KFS,KSS,KFF \$
83	LABEL	LBL3 \$
84	EQUIV	KFF,KAA/OMIT \$
85	CHKPNT	KAA \$
86	COND	LBL5,OMIT \$
87	<u>SMP1</u>	USET,KFF,,,/GO,KAA,KOC,LOO,,,,, \$
88	CHKPNT	GO,KAA,KOO,LOO \$
89	LABEL	LBL5 \$
90	<u>RBMG2</u>	KAA/LLL \$
91	CHKPNT	LLL \$
92	<u>SSG1</u>	SLT,BGPD,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/ V,N, LUSET/C,N,1 \$
93	CHKPNT	PG \$
94	EQUIV	PG,PL/NOSET \$
95	CHKPNT	PL \$
96	COND	LBL10,NOSET \$
97	<u>SSG2</u>	USET,GM,YS,KFS,GO,,PG/,PO,PS,PL \$
98	CHKPNT	PO,PS,PL \$
99	LABEL	LBL10 \$

BUCKLING ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

100	(SSG3)	LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/ C,N,1/V,N,EPSI \$
101	SAVE	EPSI \$
102	CHKPNT	ULV,UOOV,RULV,RUOV \$
103	COND	LBL9,IRES \$
104	MATGPR	GPL,USET,SIL,RULV//C,N,L \$
105	MATGPR	GPL,USET,SIL,RUOV//C,N,O \$
106	LABEL	LBL9 \$
107	(SDR1)	USET,PG,ULV,UOOV,YS,GQ,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N, BKLO \$
108	CHKPNT	UGV,QG,PGG \$
109	(SDR2)	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPD,.,QG,UGV,EST,PGG/ OPG1,OQG1,OUGV1,OES1,DEF1,PUGV1/C,N,BKLO \$
111	OPF	OUGV1,OPG1,OQG1,DEF1,OES1,./V,N,CARDNO \$
112	SAVE	CARDNO \$
113	COND	P2,JUMPPLOT \$
114	(PLOT)	PLTPAR,GPSETS,ELSETS,CASECC,BGPD,EQEXIN,SIL,PUGV1,,GPECT,OES1/ PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
115	SAVE	PFILE \$
116	PRTMSG	PLOTX2// \$
117	LABEL	P2 \$
118	(TA1)	ECT,EPT,BGPD,SIL,GPTT,CSTM/X1,X2,ECPT,GPCT/V,N,LUSET/ V,N, NOSIMP/C,N,O/V,N,NOGENL/V,N,GENEL \$
119	(DSMG1)	CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/ V,N, DSCSET \$
120	CHKPNT	KDGG \$
121	EQUIV	KDGG,KDNN/MPCF2 \$
122	CHKPNT	KDNN \$
123	COND	LBL2D,MPCF2 \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 5

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

124	(MCE2)	USET,GM,KDGG,,,/KDNN,,, \$
125	CHKPNT	KDNN \$
126	LABEL	LBL2D \$
127	EQUIV	KDNN,KDFF/SINGLE \$
128	CHKPNT	KDFF \$
129	COND	LBL3D,SINGLE \$
130	(SCE1)	USET,KDNN,,,/KDFF,KDFS,,,, \$
131	CHKPNT	KDFF,KDFS \$
132	LABEL	LBL3D \$
133	EQUIV	KDFF,KDAA/OMIT \$
134	CHKPNT	KDAA \$
135	COND	LBL5D,OMIT \$
136	(SMP2)	USET,GO,KDFF/KDAA \$
137	CHKPNT	KDAA \$
138	LABEL	LBL5D \$
139	ADD	KDAA,/KDAAM/C,N,(-1.0,0.0)/C,N,(0.0,0.0) \$
140	CHKPNT	KDAAM \$
141	(DPD)	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,EED,EQDYN/V,N, LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/ N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE \$ V,
142	SAVE	NOEED \$
143	COND	ERROR3,NOEED \$
144	CHKPNT	EED \$
145	PARAM	//C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 \$
146	(READ)	KAA,KDAAM,,,EED,USET,CASECC/LAMA,PHIA,,OEIGS/C,N,BUCKLING/ NEIGV/C,N,2 \$ V,N,
147	SAVE	NEIGV \$
148	CHKPNT	LAMA,PHIA,OEIGS \$

BUCKLING ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

149	OFF	DEIGS,LAMA,,,//V,N,CARDNO \$
150	SAVE	CARDNO \$
151	COND	ERROR4,NEIGV \$
152	SDR1	USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,BQG/C,N,1/C,N,BKL1 \$
153	CHKPNT	PHIG,BQG \$
154	SDR2	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,BQG,PHIG,EST,,/, OBQG1,OPHIG,OBES1,OBEF1,PPHIG/C,N,BKL1 \$
155	OFF	OPHIG,OBQG1,OBEF1,OBES1,,,//V,N,CARDNO \$
156	SAVE	CARDNO \$
157	COND	P3,JUMPPLOT \$
158	PLOT	PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,PPHIG,GPECT, OBES1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N, PFILE \$
159	SAVE	PFILE \$
160	PRMSG	PLOTX3// \$
161	LABEL	P3 \$
162	JUMP	FINIS \$
163	LABEL	ERROR1 \$
164	PRTPARM	//C,N,-1/C,N,BUCKLING \$
165	LABEL	ERROR2 \$
166	PRTPARM	//C,N,-2/C,N,BUCKLING \$
167	LABEL	ERROR3 \$
168	PRTPARM	//C,N,-3/C,N,BUCKLING \$
169	LABEL	ERROR4 \$
170	PRTPARM	//C,N,-4/C,N,BUCKLING \$
171	LABEL	ERROR5 \$
172	PRTPARM	//C,N,-5/C,N,BUCKLING \$
173	LABEL	ERROR6 \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 5

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

174 PRTPARM //C,N,-6/C,N,BUCKLING \$

175 LABEL FINIS \$

176 END \$

BUCKLING ANALYSIS

3.6.2 Description of DMAP Operations for Buckling Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations and tables for relating internal and external grid point numbers.
6. GP2 generates Element Connection Table with internal indices.
10. Go to DMAP No. 20 if no plot package is present.
11. PLTSET transforms user input into a form used to drive structure plotter.
13. PRTMSG prints error messages associated with structure plotter.
16. Go to DMAP No. 20 if no undeformed structure plot request.
17. PLØT generates all requested undeformed structure plots.
19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
22. GP3 generates Static Loads Table and Grid Point Temperature Table.
26. TA1 generates element tables for use in matrix assembly and stress recovery.
28. Go to DMAP No. 163 and print error message if no structural elements.
32. EMG generates structural element matrix tables and dictionaries for later assembly.
35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.
36. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
39. Go to DMAP No. 42 if no mass matrix is to be assembled.
40. EMA assembles mass matrix $[M_{gg}]$.
43. Go to DMAP No. 47 if no gravity loads and no weight and balance request.
44. Go to DMAP No. 171 and print error message if no mass matrix exists.
45. GPWG generates weight and balance information.
46. ØFP formats weight and balance information and places it on the system output file for printing.
48. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
50. Go to DMAP No. 53 if no general elements.
51. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
55. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.
57. Go to DMAP No. 173 and print error message if no independent degrees of freedom are defined.
61. Go to DMAP No. 63 if no free-body supports supplied.
62. Go to DMAP No. 165 and print error message if free-body supports are present.
64. Go to DMAP No. 69 if general elements present.
65. GPSP determines if possible grid point singularities remain.

RIGID FORMATS

67. Go to DMAP No. 69 if no Grid Point Singularity Table.
68. ØFP formats table of possible grid point singularities and places it on the system output file for printing.
70. Equivalence $[K_{aa}]$ to $[K_{nn}]$ if no multipoint constraints.
72. Go to DMAP No. 77 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
73. MCE1 partitions multipoint constraint equations $[R_g] = [R_m; R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
75. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

78. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.
80. Go to DMAP No. 88 if no single-point constraints.
81. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array} \right].$$

84. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.
86. Go to DMAP No. 89 if no omitted coordinates.
87. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

90. RBMG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$.
92. SSG1 generates static load vectors $\{P_g\}$.
94. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.
96. Go to DMAP No. 99 if no constraints applied.

BUCKLING ANALYSIS

97. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ \bar{P}_m \end{Bmatrix}, \quad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ \bar{P}_s \end{Bmatrix}, \quad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ P_o \end{Bmatrix} \text{ and } \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\}.$$

100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\},$$

solves for displacements of omitted coordinates

$$\{u_o^0\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\epsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUOV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^0\},$$

$$\epsilon_o = \frac{\{u_o^{0T}\}\{\delta P_o\}}{\{P_o^T\}\{u_o^0\}}$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. Print residual vector for independent coordinates (RULV)

105. Print residual vector for omitted coordinates (RUOV).

RIGID FORMATS

107. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_k\} + \{u_o^0\},$$

$$\begin{Bmatrix} u_a \\ u_o \end{Bmatrix} = \{u_f\}, \quad \begin{Bmatrix} u_f \\ Y_s \end{Bmatrix} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\}, \quad \begin{Bmatrix} u_n \\ u_m \end{Bmatrix} = \{u_g\},$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\}.$$

109. SDR2 calculates element forces and stresses ($\emptyset EF1$, $\emptyset ES1$) and prepares load vectors, displacement vectors and single-point forces of constraint for output ($\emptyset PG1$, $\emptyset UGV1$, $PUGV1$, $\emptyset QG1$).
111. $\emptyset FP$ formats tables prepared by SDR2 and places them on the system output file for printing.
113. Go to DMAP No. 117 if no static deformed structure plots are requested.
114. $PL\emptyset T$ generates all requested static deformed structure plots.
116. $PRTMSG$ prints plotter data and engineering data for each deformed plot generated.
118. $TA1$ generates element tables for use in differential stiffness matrix assembly.
119. $DSMGI$ generates differential stiffness matrix $[K_{gg}^d]$.
121. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.
123. Go to DMAP No. 126 if no multipoint constraints.
124. $MCE2$ partitions differential stiffness matrix

$$[K_{gg}^d] = \begin{bmatrix} \bar{K}_{nn}^d & | & K_{nm}^d \\ \hline K_{mn}^d & | & K_{mm}^d \end{bmatrix}$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

127. Equivalence $[K_{nn}^d]$ to $[K_{ff}^d]$ if no single-point constraints.
129. Go to DMAP No. 132 if no single-point constraints.
130. $SCE1$ partitions out single-point constraints

$$[K_{nn}^d] = \begin{bmatrix} K_{ff}^d & | & K_{fs}^d \\ \hline K_{sf}^d & | & K_{ss}^d \end{bmatrix}.$$

133. Equivalence $[K_{ff}^d]$ to $[K_{aa}^d]$ if no omitted coordinates.
135. Go to DMAP No. 138 if no omitted coordinates.

BUCKLING ANALYSIS

136. SMP2 partitions constrained differential stiffness matrix

$$[K_{ff}^d] = \begin{bmatrix} \bar{K}_{aa}^d & | & K_{ao}^d \\ \hline K_{oa}^d & | & K_{oo}^d \end{bmatrix}$$

and performs matrix reduction $[K_{aa}^d] = [\bar{K}_{aa}^d] + [K_{oa}^d]^T [G_o] + [G_o]^T [K_{oa}^d] + [G_o]^T [K_{oo}^d] [G_o]$.

141. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

143. Go to DMAP No. 167 and print error message if no Eigenvalue Extraction Data.

146. READ extracts real eigenvalues from the equation

$$[K_{\ell\ell} + \lambda K_{\ell\ell}^d] \{u_\ell\} = 0$$

and normalizes eigenvectors according to one of the following user requests:

- 1) Unit value of selected coordinate
- 2) Unit value of largest component

149. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

151. Go to DMAP No. 169 and print error message if no eigenvalues found.

152. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o] \{\phi_a\}, \quad \begin{Bmatrix} \phi_a \\ \phi_o \end{Bmatrix} = \{\phi_f\},$$

$$\begin{Bmatrix} \phi_f \\ \phi_s \end{Bmatrix} = \{\phi_n\}, \quad \{\phi_m\} = [G_m] \{\phi_n\},$$

$$\begin{Bmatrix} \phi_n \\ \phi_m \end{Bmatrix} = \{\phi_g\}$$

and recovers single point forces of constraint $\{q_s\} = [K_{fs}^T] \{\phi_f\}$.

154. SDR2 calculates element forces and stresses (ØBEF1, ØBES1) and prepares eigenvectors and single-point forces of constraint for output (ØPHIG, PPHIG, ØBQG1).

155. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

157. Go to DMAP No. 161 if no deformed (buckling) structure plots are requested.

158. PLØT generates all requested deformed (buckling) structure plots.

160. PRTMSG prints plotter data and engineering data for each deformed plot generated.

162. Go to DMAP No. 175 and make normal exit.

164 BUCKLING ANALYSIS ERROR MESSAGE NO. 1 - NO STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

RIGID FORMATS

- 166. BUCKLING ANALYSIS ERROR MESSAGE NO. 2 - FREE BODY-SUPPORTS NOT ALLOWED.
- 168. BUCKLING ANALYSIS ERROR MESSAGE NO. 3 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.
- 170. BUCKLING ANALYSIS ERROR MESSAGE NO. 4 - NO EIGENVALUES FOUND.
- 172. BUCKLING ANALYSIS ERROR MESSAGE NO. 5 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.
- 174. BUCKLING ANALYSIS ERROR MESSAGE NO. 6 - NO INDEPENDENT DEGREES OF FREEDOM HAVE BEEN DEFINED.

BUCKLING ANALYSIS

3.6.3 Automatic Output for Buckling Analysis

The summary of the eigenvalues associated with the buckling modes and the summary of the eigenvalue analysis performed, as described in the Normal Mode Analysis rigid format, are automatically printed.

3.6.4 Case Control Deck and Parameters for Buckling Analysis

The following items relate to subcase definition and data selection for Buckling Analysis:

1. The Case Control Deck must contain at least two subcases. Subcases beyond the second are used only for output selection.
2. METHØD must appear in the second subcase to select an EIGB card from the Bulk Data Deck.
3. A static loading condition must be defined in the first subcase with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection, unless all loading is specified by grid point displacements on SPC cards.
4. An SPC set must be selected above the subcase level, unless all constraints are specified on GRID cards.
5. Output requests that apply only to the solution under static load must be placed in the first subcase.
6. Output requests that apply to the buckling solution only must be placed in the second and succeeding subcases. If only two subcases exist, the output requests in the second subcase will be honored for all buckling modes.
7. Output requests that apply to both the static solution and the buckling modes may be placed above the subcase level.

The following output may be requested for Buckling Analysis:

1. Displacements and nonzero components of the static loads and single-point forces of constraint at selected grid points for the static analysis.
2. Forces and stresses in selected elements for the static loading condition.
3. Mode shapes and nonzero components of the single-point forces of constraint at selected grid points for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected buckling modes.

RIGID FORMATS

The following parameters are used in Buckling Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.
3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.
4. C0UPMASS - CPBAR, CPR0D, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

PIECEWISE LINEAR ANALYSIS

3.7 PIECEWISE LINEAR ANALYSIS

3.7.1 DMAP Sequence for Piecewise Linear Analysis

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NO.6 PIECEWISE LINEAR STATIC ANALYSIS - SERIES N $
2 FILE      QG1=APPEND/UGV1=APPEND/KGGSUM=SAVE/PGV1=APPEND $
3 GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPD,T,SIL/V,N,LUSET/ V,N,
            NOGPDT $
4 SAVE      LUSET $
5 CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPD,T,SIL $
6 GP2       GEOM2,EQEXIN/ECT $
7 CHKPNT    ECT $
8 PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
9 PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
10 COND     P1,NOPCDB $
11 PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
            JUMPPLOT=-1 $
12 SAVE     NSIL,JUMPPLOT $
13 PRTMSG    PLTSETX// $
14 PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
15 PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
16 COND     P1,JUMPPLOT $
17 PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPD,T,EQEXIN,SIL,,,/PLOTX1/ V,N,
            NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
18 SAVE     JUMPPLOT,PLTFLG,PFILE $
19 PRTMSG    PLOTX1// $
20 LABEL    P1 $
21 CHKPNT    PLTPAR,GPSETS,ELSETS $
22 GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $
23 SAVE     NOGRAV $
24 PARAM     //C,N,AND/V,N,SKPMGG/V,N,NOGRAV/V,Y,GRDPNT $

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RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 6

NASTRAN SOURCE PROGRAM COMPILATION DMAP-DMAP INSTRUCTION NO.

```

25  CHKPNT  SLT,GPTT $
26  (TA1)   ECT,EPT,BGPD,T,SIL,GPTT,CSTM/EST,GEI,ECPT ,GPCT/V,N,LUSET/  V,
           N,NOSIMP/C,N,O/V,N,NOGENL/V,N,GENEL $
27  SAVE    NOSIMP,NOGENL,GENEL $
28  PARAM   //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $
29  COND    ERROR4,NOELMT $
30  PURGE   GPST/NOSIMP/OGPST/GENEL $
31  CHKPNT  EST,ECPT,GPCT,GEI,GPST,OGPST $
32  COND    LBL1,NOSIMP $
33  (SMA1)  CSTM,MPT,ECPT,GPCT,DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG $
34  CHKPNT  GPST,KGGX $
35  COND    LBL1,SKPMGG $
36  (SMA2)  CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
           C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,
           CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,
           CPTRBSC $
37  SAVE    NOMGG $
38  CHKPNT  MGG $
39  COND    LBL1,GRDPNT $
40  COND    ERROR3,NOMGG $
41  (GPWG)  BGPD,T,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $
42  OFP     OGPWG,,,,,// $
43  LABEL   LBL1 $
44  (PLA1)  CSTM,MPT,ECPT,GPCT,DIT,CASECC,EST/KGGXL,ECPTNL,ESTL,ESTNL/V,N,
           KGGLPG/V,N,NPLALIM/V,N,ECPTNLPG/V,N,PLSETNO/V,N,NONLSTR/V,N,
           PLFACT $
45  SAVE    KGGLPG,NPLALIM,ECPTNLPG,PLSETNO,NONLSTR,PLFACT $
46  COND    ERROR1,ECPTNLPG $
47  PURGE   ONLES,ESTNL1/NONLSTR $

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PIECEWISE LINEAR ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 6

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

```

48  CHKPNT   KGGXL,ECPTNL,ESTL,ESTNL,ESTNL1 $
49  PARAM    //C,N,ADD/V,N,ALWAYS/C,N,-1/C,N,0 $
50  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $
51  EQUIV    KGGX,KGG/NOGENL/KGGXL,KGGL/NOGENL $
52  CHKPNT   KGG,KGGL $
53  COND     LBL11,NOGENL $
54  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
55  CHKPNT   KGG $
56  SMA3     GEI,KGGXL/KGGL/V,N,LUSET/V,N,NOGENL/V,N,KGGLPG $
57  CHKPNT   KGGL $
58  LABEL    LBL11 $
59  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
60  GP4      CASECC,GEOM4,EQEXIN,SIL,GPD,T,BGPD,T,CSTM/RG,YS,USE,T,ASET/V,N,
            LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
            NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
61  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $
62  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $
63  PURGE    KRR,KLR,QR,DM/REACT/GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,
            KFS,KSS/SINGLE/QG/NOSR $
64  CHKPNT   KRR,KLR,QR,DM,GM,GO,KOO,LOO,PO,UOOV,QG,PS,KFS,KSS,USE,T,RG,YS,
            RUOV $
65  SSG1     SLT,BGPD,T,CSTM,SIL,EST,MPT,,,MGG,CASECC,DIT/PG1/V,N,    LUSET/C,
            N,1 $
66  CHKPNT   PG1 $
67  EQUIV    PG1,PL/NOSET $
68  CHKPNT   PL $
69  COND     LBL4,GENEL $
70  GPSP     GPL,GPST,USE,T,SIL/OGPST/V,N,NOGPST $
71  SAVE     NOGPST $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 6

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

72	COND	LBL4,NOGPST \$
73	DFP	DGPST,,,,,//\$
74	LABEL	LBL4 \$
75	PARAM	//C,N,ADD/V,N,PLACOUNT/C,N,1/C,N,0 \$
76	EQUIV	KGG,KNN/MPCF1 \$
77	CHKPNT	KNN \$
78	COND	LBL2,MPCF2 \$
79	MCE1	USET,RG/GM \$
80	CHKPNT	GM \$
81	PARAM	//C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 \$
82	JUMP	LOOPBGN \$
83	LABEL	LOOPBGN \$
84	EQUIV	KGG,KNN/MPCF2 \$
85	CHKPNT	KNN \$
86	COND	LBL2,MPCF2 \$
87	MCE2	USET,GM,KGG,,,/KNN,,, \$
88	CHKPNT	KNN \$
89	LABEL	LBL2 \$
90	EQUIV	KNN,KFF/SINGLE \$
91	CHKPNT	KFF \$
92	COND	LBL3,SINGLE \$
93	SCE1	USET,KNN,,,/KFF,KFS,KSS,,, \$
94	CHKPNT	KFS,KSS,KFF \$
95	LABEL	LBL3 \$
96	EQUIV	KFF,KAA/OMIT \$
97	CHKPNT	KAA \$

Top of DMAP Loop

PIECEWISE LINEAR ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

98	COND	LBL5,OMIT \$
99	<u>SMP1</u>	USET,KFF,,,/GO,KAA,KGC,LOO,,,,, \$
100	CHKPNT	GO,KAA,KGC,LOO \$
101	LABEL	LBL5 \$
102	EQUIV	KAA,KLL/REACT \$
103	CHKPNT	KLL \$
104	COND	LBL6,REACT \$
105	<u>RBMG1</u>	USET,KAA,/KLL,KLR,KRR,,, \$
106	CHKPNT	KLL,KLR,KRR \$
107	LABEL	LBL6 \$
108	<u>DECOMP</u>	KLL/LLL,/C,N,1/C,N,0/V,N,MINDIAGK/V,N,DETKLLXX/V,N,IDETKLLX/ V, N,SINGKLLX \$
109	SAVE	SINGKLLX \$
110	COND	LOOPENDA,SINGKLLX \$
111	CHKPNT	LLL \$
112	COND	LBL7,REACT \$
113	<u>RBMG3</u>	LLL,KLR,KRR/DM \$
114	CHKPNT	DM \$
115	LABEL	LBL7 \$
116	<u>ADD</u>	PG1,/PG/V,N,PLFACT \$
117	CHKPNT	PG \$
118	COND	LBL10,NOSET \$
119	<u>SSG2</u>	USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL \$
120	CHKPNT	QR,PO,PS,PL \$
121	LABEL	LBL10 \$
122	<u>SSG3</u>	LLL,KLL,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/ V,N,PLACQNT/V,N,EPSI \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 6

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

123	SAVE	EPSI \$
124	CHKPNT	ULV,UOOV,RULV,RUOV \$
125	COND	LBL9,IRES \$
126	MATGPR	GPL,USET,SIL,RULV//C,N,L \$
127	MATGPR	GPL,USET,SIL,RUOV//C,N,O \$
128	LABEL	LBL9 \$
129	<u>SDR1</u>	USET,PG,ULV,UOOV,YS,GD,GM,PS,KFS,KSS,QR/DELTAUGV,DELTAPG, DELTAQG/C,N,1/C,N,STATICS \$
130	CHKPNT	DELTAUGV,DELTAPG,DELTAQG \$
131	<u>PLA2</u>	DELTAUGV,DELTAPG,DELTAQG/UGV1,PGV1,QG1/V,N,PLACOUNT \$
132	SAVE	PLACOUNT \$
133	CHKPNT	UGV1,QG1,PGV1 \$
134	EQUIV	ESTNL,ESTNL1/NEVER/ECPTNL,ECPTNL1/NEVER \$
135	COND	PLALBL2A,NONLSTR \$
136	<u>PLA3</u>	CSTM,MPT,DIT,DELTAUGV,ESTNL,CASECC/ONLES,ESTNL1/V,N,PLACOUNT/ V,N,PLSETNO \$
137	CHKPNT	ESTNL1 \$
138	OFF	ONLES,,,,,//V,N,CARDNO \$
139	SAVE	CARDNO \$
140	LABEL	PLALBL2A \$
141	PARAM	//C,N,SUB/V,N,DIFF/V,N,NPLALIM/V,N,PLACOUNT \$
142	COND	LOOPEND,DIFF \$
143	<u>PLA4</u>	CSTM,MPT,ECPTNL,GPCT,DIT,DELTAUGV/KGGNL,ECPTNL1/V,N,PLACOUNT/V, N,PLSETNO/V,N,PLFACT \$
144	SAVE	PLACOUNT,PLSETNO,PLFACT \$
145	CHKPNT	KGGNL,ECPTNL1 \$
146	EQUIV	KGGNL,KGGSUM/KGGLPG \$
147	CHKPNT	KGGSUM \$

PIECEWISE LINEAR ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

148	COND	PLALBL3,KGGLPG \$
149	ADD	KGGNL,KGGL/KGGSUM \$
150	CHKPNT	KGGSUM \$
151	LABEL	PLALBL3 \$
152	EQUIV	KGGSUM,KGG/ALWAYS \$
153	CHKPNT	KGG \$
154	EQUIV	ESTNL1,ESTNL/ALWAYS/ECPTNL1,ECPTNL/ALWAYS \$
155	CHKPNT	ESTNL,ECPTNL \$
156	COND	PLALBL4,ALWAYS \$
157	PLA2	KGGSUM,KGG,/,/,/C,N,0 \$
158	PLA2	ESTNL1,ECPTNL1,/,/,/C,N,0 \$
159	LABEL	PLALBL4 \$
160	REPT	LOOPBGN,100 \$
		Bottom of DMAP Loop
161	JUMP	ERROR2 \$
162	LABEL	LOOPENDA \$
163	PRTPARM	//C,N,+5/C,N,PLA \$
164	LABEL	LOOPEND \$
165	SDR2	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDOT,,QG1,UGV1,ESTL,, PGV1/OPG1,OQG1,OUGV1,OES1,DEF1,PUGV1/C,N,PLA \$
166	DFP	OUGV1,OPG1,OQG1,DEF1,OES1,/,/V,N,CARDNO \$
167	SAVE	CARDNO \$
168	COND	P2,JUMPPLOT \$
169	PLOT	PLTPAR,GPSETS,ELSETS,CASECC,BGPDOT,EQEXIN,SIL,PUGV1,,ECPT,OES1/ PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
170	SAVE	PFILE \$
171	PRTMSG	PLOTX2// \$
172	LABEL	P2 \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 6

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

173	JUMP	FINIS \$
174	LABEL	ERROR1 \$
175	PRTPARM	//C,N,-1/C,N,PLA \$
176	LABEL	ERROR2 \$
177	PRTPARM	//C,N,-2/C,N,PLA \$
178	LABEL	ERROR3 \$
179	PRTPARM	//C,N,-3/C,N,PLA \$
180	LABEL	ERROR4 \$
181	PRTPARM	//C,N,-4/C,N,PLA \$
182	LABEL	FINIS \$
183	END	\$

PIECEWISE LINEAR ANALYSIS

3.7.2 Description of DMAP Operations for Piecewise Linear Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
6. GP2 generates Element Connection Table with internal indices.
10. Go to DMAP No. 20 if no plot package is present.
11. PLTSET transforms user input into a form used to drive structure plotter.
13. PRTMSG prints error messages associated with structure plotter.
16. Go to DMAP No. 20 if no undeformed structure plot request.
17. PLØT generates all requested undeformed structure plots.
19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
22. GP3 generates Static Loads Table and Grid Point Temperature Table.
26. TA1 generates element tables for use in matrix assembly and stress recovery.
29. Go to DMAP No. 180 and print error message if no elements have been defined.
32. Go to DMAP No. 43 if there are no structural elements.
33. SMA1 generates stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
35. Go to DMAP No. 43 if no gravity loads and no weight and balance request.
36. SMA2 generates mass matrix $[M_{gg}]$.
39. Go to DMAP No. 43 if no weight and balance request.
40. Go to DMAP No. 178 and print error message if no mass matrix exists.
41. GPWG generates weight and balance information.
42. ØFP formats weight and balance information and places it on the system output file for printing.
44. PLA1 extracts the linear terms from $[K_{gg}^x]$ to give $[K_{gg}^{x\ell}]$, extracts the nonlinear entries from the Element Connection and Properties Table to give ECPTNL, and separates the linear and nonlinear entries in the Element Summary Table to give ESTL and ESTNL.
46. Go to DMAP No. 174 and print error message if no elements have a stress dependent modulus of elasticity.
51. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ and $[K_{gg}^{x\ell}]$ to $[K_{gg}^\ell]$ if no general elements.
53. Go to DMAP No. 58 if no general elements.
54. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
56. SMA3 adds general elements to $[K_{gg}^{x\ell}]$ to obtain stiffness matrix of linear elements $[K_{gg}^\ell]$.
60. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

RIGID FORMATS

65. SSG1 generates total static load vector $\{P_g^1\}$.
67. Equivalence $\{P_g^1\}$ to $\{P_\ell\}$ if no constraints applied.
69. Go to DMAP No. 74 if general elements present.
70. GPSP determines if possible grid point singularities remain.
72. Go to DMAP No. 74 if no Grid Point Singularity Table.
73. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.
76. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.
78. Go to DMAP No. 89 if no multipoint constraints.
79. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
82. Beginning of loop for Piecewise Linear Analysis.
84. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.
86. Go to DMAP No. 91 if no multipoint constraints.
87. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

90. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.
92. Go to DMAP No. 95 if no single-point constraints.
93. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array} \right]$$

96. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.
98. Go to DMAP No. 101 if no omitted coordinates.
99. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

PIECEWISE LINEAR ANALYSIS

102. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

104. Go to DMAP No. 107 if no free-body supports.

105. RBMG1 partitions out free-body supports

$$[K_{aa}] = \begin{bmatrix} K_{\ell\ell} & K_{\ell r} \\ K_{r\ell} & K_{rr} \end{bmatrix}$$

108. DECØMP decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

110. Go to DMAP No. 166 if stiffness matrix $[K_{\ell\ell}]$ is singular (i.e., local plasticity).

112. Go to DMAP No. 117 if no free-body supports.

113. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}$$

116. Multiply total load vector $\{P_g^1\}$ by factor to obtain applied load vector $\{P_g\}$ for current loop.

118. Go to DMAP No. 121 if no constraints applied.

119. SSG2 applies constraints to static load vector for current loop.

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ \bar{P}_m \end{Bmatrix}, \quad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ \bar{P}_s \end{Bmatrix}, \quad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \begin{Bmatrix} \bar{P}_a \\ \bar{P}_o \end{Bmatrix}, \quad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \begin{Bmatrix} P_\ell \\ P_r \end{Bmatrix}$$

and calculates incremental determinate forces of reaction for current loop

$$\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}.$$

RIGID FORMATS

122.. SSG3 solves for displacements of independent coordinates

$$\{u_{\ell}\} = [K_{\ell\ell}]^{-1}\{P_{\ell}\},$$

solves for displacements of omitted coordinates

$$\{u_0^0\} = [K_{00}]^{-1}\{P_0\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_{\ell}\} = \{P_{\ell}\} - [K_{\ell\ell}]\{u_{\ell}\}.$$

$$\epsilon_{\ell} = \frac{\{u_{\ell}^T\}\{\delta P_{\ell}\}}{\{P_{\ell}^T\}\{u_{\ell}\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_0\} = \{P_0\} - [K_{00}]\{u_0^0\},$$

$$\epsilon_0 = \frac{\{u_0^T\}\{\delta P_0\}}{\{P_0^T\}\{u_0^0\}}$$

125. Go to DMAP No. 128 if residual vectors are not to be printed.

126. Print residual vector for independent coordinates (RULV)

127. Print residual vector for omitted coordinates (RUØV).

129. SDR1 recovers dependent incremental displacements for current loop

$$\begin{pmatrix} u_{\ell} \\ u_r \end{pmatrix} = \{u_a\}, \quad \{u_0\} = [G_0]\{u_a\} + \{u_0^0\},$$

$$\begin{pmatrix} u_a \\ u_o \end{pmatrix} = \{u_f\}, \quad \begin{pmatrix} u_f \\ y_s \end{pmatrix} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\}, \quad \begin{pmatrix} u_n \\ u_m \end{pmatrix} = \{u_g\}.$$

and recovers incremental single-point forces of constraint for current loop

$$\{\delta q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}.$$

131. PLA2 adds the incremental displacement vector and the incremental single-point forces of constraint vector for the current loop to the accumulated sum of these vectors.

$$\{u_{g_{i+1}}\} = \{\delta u_{g_i}\} + \{u_{g_i}\} \quad \text{and}$$

$$\{q_{g_{i+1}}\} = \{\delta q_{g_i}\} + \{q_{g_i}\}.$$

PIECEWISE LINEAR ANALYSIS

134. Allocate separate files for ESTNL and ESTNL1 and for ECPTNL and ECPTNL1.
135. Go to DMAP No. 140 if no stress output requested for nonlinear elements.
136. PLA3 calculates incremental stresses in nonlinear elements for which an output request has been made and updates the accumulated stresses in these elements.
138. ØFP formats the accumulated stresses in nonlinear elements and places them on the system output file for printing.
142. Go to DMAP No. 164 if all loading increments have been completed.
143. PLA4 generates stiffness matrix for nonlinear elements and updates stress information in ECPTNL.
146. Equivalence $[K_{gg}^{nl}]$ to $[K_{gg}]$ if all elements are nonlinear.
148. Go to DMAP No. 151 if all elements are nonlinear.
149. Add stiffness matrix for nonlinear elements to stiffness matrix for linear elements
$$[K_{gg}^{nl}] + [K_{gg}^l] = K_{GGSUM}$$
152. Equivalence K_{GGSUM} to $[K_{gg}]$ for next pass through loop.
154. Equivalence existing element tables to updated tables for next pass through loop.
156. Go to DMAP No. 159 - next two instructions are never executed.
157. PLA2 is used to define K_{GGSUM} .
158. PLA2 is used to define ESTNL1 and ECPTNL1.
160. Go to DMAP No. 83 if additional load increments need to be processed.
161. Go to DMAP No. 176 and print error message if more than 100 loops.
162. End of loop for Piecewise Linear Analysis when local plasticity occurs in K_{ll} .
163. PIECEWISE LINEAR ANALYSIS ERROR MESSAGE NO. 5 - STIFFNESS MATRIX SINGULAR DUE TO MATERIAL PLASTICITY.
164. End of loop for Piecewise Linear Analysis.
165. SDR2 calculates element forces and stresses for linear elements (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).
166. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.
168. Go to DMAP No. 172 if no deformed structure plots are requested.
169. PLØT generates all requested deformed structure plots.
171. PRTMSG prints plotter data and engineering data for each deformed plot generated.
173. Go to DMAP No. 182 and make normal exit.
175. PIECEWISE LINEAR ANALYSIS ERROR MESSAGE NO. 1 - NO NONLINEAR ELEMENTS HAVE BEEN DEFINED.
177. PIECEWISE LINEAR ANALYSIS ERROR MESSAGE NO. 2 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

RIGID FORMATS

179. PIECEWISE LINEAR ANALYSIS ERROR MESSAGE NO. 3 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.
181. PIECEWISE LINEAR ANALYSIS ERROR MESSAGE NO. 4 - NO ELEMENTS HAVE BEEN DEFINED.

PIECEWISE LINEAR ANALYSIS

3.7.3 Case Control Deck and Parameters for Piecewise Linear Analysis

The following items relate to subcase definition and data selection for Piecewise Linear Analysis:

1. The Case Control Deck must contain one and only one subcase.
2. A static loading condition must be defined with a LOAD selection.
3. An SPC set must be selected unless all constraints are specified on GRID cards.
4. PLCOEFFICIENT must appear either to select a PLFACT set from the Bulk Data Deck or to explicitly select the default value of unity.

The following output may be requested for Piecewise Linear Analysis:

1. Accumulated sums of displacements and nonzero components of the static loads and single-point forces of constraint at selected grid points for each load increment.
2. Stresses in selected elements. If an element is composed of a nonlinear material the accumulated stress will be output for each load increment. Stresses in linear elements are only calculated for the total load.
3. Undeformed plot of the structural model and deformed plots for each load increment.

The following parameters are used in Piecewise Linear Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.
3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.
4. COUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

DIRECT COMPLEX EIGENVALUE ANALYSIS

3.8 DIRECT COMPLEX EIGENVALUE ANALYSIS

3.8.1 DMAP Sequence for Direct Complex Eigenvalue Analysis

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 7

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NO.7 DIRECT COMPLEX EIGENVALUE ANALYSIS - SERIES N $
2 FILE      KGGX=TAPE/ KGG=TAPE/ GUD=SAVE/ GMD=SAVE $
3 GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/ V,N,
            NOGPDT $
4 SAVE      LUSET,NOGPDT $
5 PURGE     USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,EST,ECT,PLTSETX,PLTPAR,GPSETS,
            ELSETS/NOGPDT $
6 CHPNT     GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,EST,
            ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $
7 COND      LBL5,NOGPDT $
8 GP2       GEOM2,EQEXIN/ECT $
9 CHPNT     ECT $
10 PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
11 PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
12 COND     P1,NOPCDB $
13 PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
            JUMPPLUT=-1 $
14 SAVE     NSIL,JUMPPLUT $
15 PRTMSG   PLTSETX// $
16 PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
17 PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
18 COND     P1,JUMPPLUT $
19 PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,/PLOTX1/ V,N,
            NSIL/V,N,LUSET/V,N,JUMPPLUT/V,N,PLTFLG/V,N,PFILE $
20 SAVE     PFILE $
21 PRTMSG   PLOTX1// $
22 LABEL    P1 $
23 CHPNT    PLTPAR,GPSETS,ELSETS $
24 GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NUGRAV $
25 CHPNT    GPTT $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 7

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

26	TAL	ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N, NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL \$
27	SAVE	NOSIMP,NOGENL,GENEL \$
28	PURGE	K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA, KGGX/NOSIMP / OGPST/GENEL \$
29	CHKPNT	EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST, K4NN,K4FF,K4AA, MNN,MFF,MAA,BNN,BFF,BAA \$
30	COND	LBL1,NOSIMP \$
31	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
32	PARAM	//C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 \$
33	PARAM	//C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 \$
34	PARAM	//C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 \$
35	EMG	EST,CSTM,MPT,DIT,GEUM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/V,N, NOKGGX/V,N,NUMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y, CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y, CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
36	SAVE	NOKGGX,NUMGG,NOBGG,NOK4GG \$
37	CHKPNT	KELM,KDICT,MELM,MDICT,BELM,BDICT \$
38	COND	LBLKGGX,NOKGGX \$
39	EMA	GPECT,KDICT,KELM/KGGX,GPST \$
40	CHKPNT	KGGX,GPST \$
41	LABEL	LBLKGGX \$
42	COND	LBLMGG,NOMGG \$
43	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
44	CHKPNT	MGG \$
45	LABEL	LBLMGG \$
46	COND	LBLBGG,NOBGG \$
47	EMA	GPECT,BDICT,BELM/BGG, \$
48	CHKPNT	BGG \$
49	LABEL	LBLBGG \$
50	COND	LBLK4GG,NOK4GG \$

DIRECT COMPLEX EIGENVALUE ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 7

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

51 EMA GPECT,KDICT,KELM/K4GG,/V,N,NUK4GG $
52 CHKPNT K4GG $
53 LABEL LBLK4GG $
54 PURGE MNN,MFF,MAA/NOIMG $
55 PURGE BNN,BFF,BAA/NOBGG $
56 CHKPNT MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $
57 COND LBL1,GRDPNT $
58 COND ERROR3,NOIMG $
59 GPWG BGPDT,CSTM,EQEXIN,MGG/DGPWG/V,Y,GRDPNT/C,Y,WTMASS $
60 OFP DGPWG,,,,,/$
61 LABEL LBL1 $
62 EQUIV KGGX,KGG/NOGENL $
63 CHKPNT KGG $
64 COND LBL11,NOGENL $
65 SMA3 GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
66 CHKPNT KGG $
67 LABEL LBL11 $
68 PARAM //C,N,MPY/V,N,NSKIP/C,N,O/C,N,O $
69 GP4 CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/ V,N,
LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
NSKIP/V,N,REPEAT/V,N,NOSET=-1/V,N,NOL/V,N,NUA=-1/ C,Y,SUBID $
70 SAVE MPCF1,MPCF2,SINGLE,OMIT,NSKIP,NOSET,REACT,REPEAT,NOL,NUA $
71 PURGE GM,GMD/MPCF1/GO,GOD/OMIT/KFS,QPC/SINGLE $
72 CHKPNT GM,GMD,RG,GO,GOD,KFS,QPC $
73 COND LBL4,GENEL $
74 COND LBL4,NOSIMP $
75 GPSP GPL,GPST,USET,SIL/DGPST/V,N,NOGPST $
76 SAVE NOGPST $
77 COND LBL4,NOGPST $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 7

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

78	DFP	UGPST,,,,,// \$
79	LABEL	LBL4 \$
80	EQUIV	KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 \$
81	CHKPNT	KNN,MNN,BNN,K4NN \$
82	COND	LBL2,MPCF2 \$
83	MCE1	USET,RG/GM \$
84	CHKPNT	GM \$
85	MCE2	USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN \$
86	CHKPNT	KNN,MNN,BNN,K4NN \$
87	LABEL	LBL2 \$
88	EQUIV	KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE \$
89	CHKPNT	KFF,MFF,BFF,K4FF \$
90	COND	LBL3,SINGLE \$
91	SCE1	USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF \$
92	CHKPNT	KFS,KFF,MFF,BFF,K4FF \$
93	LABEL	LBL3 \$
94	EQUIV	KFF,KAA/OMIT/ MFF,MAA/OMIT/BFF,BAA/OMIT/K4FF,K4AA/OMIT \$
95	CHKPNT	KAA,MAA,BAA,K4AA \$
96	COND	LBL5,OMIT \$
97	SMP1	USET,KFF,,,/GO,KAA,KOD,LOU,,,,, \$
98	CHKPNT	GO,KAA \$
99	COND	LBLM,NOMGG '\$
100	SMP2	USET,GO,MFF/MAA \$
101	CHKPNT	MAA \$
102	LABEL	LBLM \$
103	COND	LBLB,NDBGG \$
104	SMP2	USET,GO,BFF/BAA \$
105	CHKPNT	BAA \$

DIRECT COMPLEX EIGENVALUE ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 7

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

106	LABEL	LBLB \$
107	COND	LBL5,NOK4GG \$
108	SMP2	USET,GO,K4FF/K4AA \$
109	CHKPNT	K4AA \$
110	LABEL	LBL5 \$
111	DPD	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,EED,EQDYN/V, N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NUPSDL/V,N,NOFRL/ V,N,NOFLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE \$
112	SAVE	LUSETD,NOUE \$
113	EQUIV	GO,GOD/NOUE/GM,GMD/NOUE \$
114	CHKPNT	USETD,EED,EQDYN,TFPOOL,GOD,GMD,SILD,GPLD \$
115	PARAM	//C,N,ADD/V,N,NEVER/C,N,1/C,N,0 \$
116	PARAM	//C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 \$
117	BMG	MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/V,N, MFACT \$
118	SAVE	MFACT,NOKBFL,NOABFL \$
119	PARAM	//C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL \$
120	PURGE	KBFL/NOKBFL/ ABFL/NOABFL \$
121	COND	LBLFL3,NOFL \$
122	MTRXIN	,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C, N,0 \$
123	SAVE	NOABFL,NOKBFL \$
124	LABEL	LBLFL3 \$
125	CHKPNT	ABFL,KBFL \$
126	PARAM	//C,N,MPY/V,N,CARUND/C,N,0/C,N,0 \$
127	JUMP	LBL13 \$
Top of DMAP Loop		
128	LABEL	LBL13 \$
129	PURGE	PHID,CLAMA,OPHID,OQPC1,OCCHIP,DESC1,DEFC1,CCHIP,QPC, K2PP, M2PP,B2PP,K2DD,M2DD,B2DD/NEVER \$
130	CASE	CASECC,/CASEXX/C,N,CEIGN/V,N,REPEATE/V,N,NOLoop \$
131	SAVE	REPEATE,NULoop \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 7

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

132	CHKPNT	CASEXX \$
133	MTRXIN	CASEXX, MAT POOL, EQDYN, , TFPOOL/K2DPP, M2DPP, B2PP/V, N, LUSETD/V, N, NUK2DPP/V, N, NOM2DPP/V, N, NOB2PP \$
134	SAVE	NOK2DPP, NOM2DPP, NOB2PP \$
135	PARAM	//C, N, AND/V, N, NOM2PP/V, N, NOABFL/V, N, NOM2DPP \$
136	PARAM	//C, N, AND/V, N, NUK2PP/V, N, NUFL /V, N, NOK2DPP \$
137	EQUIV	M2DPP, M2PP/NOABFL \$
138	ADD5	ABFL, KBFL, K2DPP, , /K2PP/C, N, (-1.0, 0.0) \$
139	COND	LBLFL2, NOABFL \$
140	TRNSP	ABFL/ABFLT \$
141	ADD	ABFLT, M2DPP/M2PP/V, N, MFACT \$
142	LABEL	LBLFL2 \$
143	PARAM	//C, N, AND/V, N, BDEBA/V, N, NOUE/V, N, NOB2PP \$
144	PARAM	//C, N, AND/V, N, MDEMA/V, N, NOUE/V, N, NUM2PP \$
145	PARAM	//C, N, AND/V, N, KDEK2/V, N, NOGENL/V, N, NOSIMP \$
146	PURGE	K2DD/NUK2PP/M2DD/NOM2PP/B2DD/NOB2PP \$
147	EQUIV	M2PP, M2DD/NOA/B2PP, B2DD/NOA/K2PP, K2DD/NOA/MAA, MDD/MDEMA/BAA, BDD/BDEBA \$
148	CHKPNT	K2PP, M2PP, B2PP, K2DD, M2DD, B2DD, BDD, MDD \$
149	COND	LBL18, NOGPD \$
150	GKAD	USETD, GM, GU, KAA, BAA, MAA, K4AA, K2PP, M2PP, B2PP/KDD, BDD, MDD, GMD, GDD, K2DD, M2DD, B2DD/C, N, CMPLV/C, N, DISP/C, N, DIRECT/C, Y, G=0.0/C, N, 0.0/C, N, 0.0/V, N, NOK2PP/V, N, NUM2PP/V, N, NOB2PP/ V, N, MPCF1/V, N, SINGLE/V, N, OMIT/V, N, NOUE/V, N, NOK4GG/V, N, NOBGG/V, N, KDEK2/C, N, -1 \$
151	LABEL	LBL18 \$
152	EQUIV	B2DD, BDD/NOBGG/ M2DD, MDD/NOSIMP/ K2DD, KDD/KDEK2 \$
153	CHKPNT	KDD, BDD, MDD, GDD, GMD \$
154	COND	ERRUR1, NOEED \$
155	CEAD	KDD, BDD, MDD, EED, CASEXX/PHID, CLAMA, OCEIGS/V, N, EIGVS \$
156	SAVE	EIGVS \$

DIRECT COMPLEX EIGENVALUE ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 7

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-UMAP INSTRUCTION
NO.

157	CHKPNT	PHID,CLAMA,UCEIGS \$
158	UFP	OCEIGS,CLAMA,,,//V,N,CARDNO \$
159	SAVE	CARDNO \$
160	COND	LBL16,EIGVS \$
161	VDR	CASEXX,EQDYN,USED,PHID,CLAMA,,/UPHID,/C,N,CEIGN/C,N,DIRECT/C, N,O/V,N,NOD/V,N,NOP/C,N,O \$
162	SAVE	NOD,NOP \$
163	COND	LBL15,NOD \$
164	UFP	UPHID,,,//V,N,CARDNO \$
165	SAVE	CARDNO \$
166	LABEL	LBL15 \$
167	COND	LBL16,NOP \$
168	EQUIV	PHID,CPHIP/NOA \$
169	COND	LBL17,NOA \$
170	SDR1	USED,, PHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1/C,N,DYNAMICS \$
171	LABEL	LBL17 \$
172	CHKPNT	CPHIP,QPC \$
173	SDR2	CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,CLAMA,QPC,CPHIP,EST,,/OQPC1, OCPHIP,DESC1,DEFCL,/C,N,CEIG \$
174	UFP	OCPHIP,OQPC1,DEFCL,DESC1,,//V,N,CARDNO \$
175	SAVE	CARDNO \$
176	LABEL	LBL16 \$
177	COND	FINIS,REPEATE \$
178	REPT	LBL13,100 \$
179	JUMP	ERROR2 \$
180	JUMP	FINIS \$
181	LABEL	ERROR2 \$
182	PRTPARM	//C,N,-2/C,N,DIRCEAD \$
183	LABEL	ERROR1 \$

Bottom of DMAP Loop

RIGID FORMATS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 7

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

184 PRTPARM //C,N,-1/C,N,DIRCEAD \$
185 LABEL ERROR3 \$
186 PRTPARM //C,N,-3/C,N,DIRCEAD \$
187 LABEL FINIS \$
188 END \$

DIRECT COMPLEX EIGENVALUE ANALYSIS

3.8.2 Description of DMAP Operations for Direct Complex Eigenvalue Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
7. Go to DMAP No. 110 if only Direct Matrix Input.
8. GP2 generates Element Connection Table with internal indices.
12. Go to DMAP No. 22 if no plot package is present.
13. PLTSET transforms user input into a form used to drive structure plotter.
15. PRTMSG prints error messages associated with structure plotter.
18. Go to DMAP No. 22 if no undeformed structure plot request.
19. PLØT generates all requested undeformed structure plots.
21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
24. GP3 generates Grid Point Temperature Table.
26. TAI generates element tables for use in matrix assembly and stress recovery.
30. Go to DMAP No. 61 if there are no structural elements.
35. EMG generates structural element matrix tables and dictionaries for later assembly.
38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.
39. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
42. Go to DMAP No. 45 if no mass matrix is to be assembled.
43. EMA assembles mass matrix $[M_{gg}]$.
46. Go to DMAP No. 49 if no viscous damping matrix.
47. EMA assembles viscous damping matrix $[B_{gg}]$.
50. Go to DMAP No. 53 if no structural damping matrix.
51. EMA assembles structural damping matrix $[K_{gg}^4]$.
57. Go to DMAP No. 61 if no weight and balance request.
58. Go to DMAP No. 185 and print error message if no mass matrix exists.
59. GPWG generates weight and balance information.
60. ØFP formats the weight and balance information and places it on the system output file for printing.
62. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
64. Go to DMAP No. 67 if no general elements.
65. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
69. GP4 generates flags defining members of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = 0$.

RIGID FORMATS

73. Go to DMAP No. 79 if general elements present.
74. Go to DMAP No. 79 if no structural elements.
75. GPSP determines if possible grid point singularities remain.
77. Go to DMAP No. 79 if no structural elements.
78. ØFP formats table of possible grid point singularities and places it on the system output file for printing.
80. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K_{gg}^4]$ to $[K_{nn}^4]$ if no multi-point constraints.
82. Go to DMAP No. 87 if MCE1 and MCE2 have already been executed for current set of multi-point constraints.
83. MCE1 partitions multipoint constraint equations $[R_g] = [R_m; R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
85. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right], \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array} \right],$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array} \right] \quad \text{and} \quad [K_{gg}^4] = \left[\begin{array}{c|c} \bar{K}_{nn}^4 & K_{nm}^4 \\ \hline K_{mn}^4 & K_{mm}^4 \end{array} \right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G_m^T][B_{mn}] + [B_{mn}^T][G_m] + [G_m^T][B_{mm}][G_m],$$

$$[K_{nn}^4] = [\bar{K}_{nn}^4] + [G_m^T][K_{mn}^4] + [K_{mn}^4]^T[G_m] + [G_m^T][K_{mm}^4][G_m].$$

88. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K_{nn}^4]$ to $[K_{ff}^4]$ if no single-point constraints.
90. Go to DMAP No. 93 if no single-point constraints.

DIRECT COMPLEX EIGENVALUE ANALYSIS

91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array} \right], \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array} \right],$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array} \right] \quad \text{and} \quad [K_{nn}^4] = \left[\begin{array}{c|c} K_{ff}^4 & K_{fs}^4 \\ \hline K_{sf}^4 & K_{ss}^4 \end{array} \right].$$

94. Equivalence $[K_{ff}]$ to $[K_{aa}]$, $[M_{ff}]$ to $[M_{aa}]$, $[B_{ff}]$ to $[B_{aa}]$ and $[K_{ff}^4]$ to $[K_{aa}^4]$ if no omitted coordinates.

96. Go to DMAP No. 110 if no omitted coordinates.

97. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1} [K_{oa}]$
and performs matrix reduction

$$[K_{aa}^1] = [K_{aa}] + [K_{ao}][G_o]$$

99. Go to DMAP No.102 if no mass matrix.

100. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array} \right]$$

and performs matrix reduction

$$[M_{aa}^1] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]$$

103. Go to DMAP No.106 if no viscous damping matrix.

RIGID FORMATS

104. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \begin{bmatrix} B_{aa} & | & B_{ao} \\ \hline & + & \\ B_{oa} & | & B_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[B_{aa}^1] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

107. Go to DMAP No. 110 if no structural damping matrix.

108. SMP2 partitions constrained structural damping matrix

$$[K_{ff}^4] = \begin{bmatrix} K_{aa}^4 & | & K_{ao}^4 \\ \hline & + & \\ K_{oa}^4 & | & K_{oo}^4 \end{bmatrix}$$

and performs matrix reduction

$$[K_{aa}^4] = [K_{aa}^4] + [K_{ao}^4][G_o] + [K_{ao}^4G_o]^T + [G_o^T][K_{oo}^4][G_o]$$

111. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.
113. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.
117. BMG generates DMIG card images describing the interconnection of the fluid and the structure.
121. Go to DMAP No. 124 if no fluid structure interface is defined.
122. MTRXIN generates fluid boundary matrices $[A_{b,fl}]$ and $[K_{b,fl}]$ if a fluid structure interface is defined. The matrix $[K_{b,fl}]$ is generated only for a nonzero gravity in the fluid.
127. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.
128. Beginning of loop for additional sets of direct input matrices.
130. CASE extracts user requests from CASECC for current loop.
133. MTRXIN selects the direct input matrices for the current loop, $[K_{pp}^{2d}]$, $[M_{pp}^{2d}]$ and $[B_{pp}^2]$.
137. Equivalence $[M_{pp}^{2d}]$ to $[M_{pp}^2]$ if no $[A_{b,fl}]$.
138. Add5 adds $[K_{b,fl}]$ and $[K_{pp}^{2d}]$ and subtracts $[A_{b,fl}]$ from them to form $[K_{pp}^2]$.
139. Go to DMAP No. 142 if no $[A_{b,fl}]$.
140. Transpose $[A_{b,fl}]$ to obtain $[A_{b,fl}]^T$.

DIRECT COMPLEX EIGENVALUE ANALYSIS

141. ADD assembles input matrix $[M_{pp}^2] = MFACT [A_{b,fl}]^T + [M_{pp}^{2d}]$.
147. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[B_{aa}]$ to $[B_{dd}]$ if no direct input damping matrices and no extra points.
149. Go to DMAP No. 151 if only extra points defined.
150. GKAD assembles stiffness, mass, and damping matrices for use in Direct Complex Eigenvalue Analysis

$$[K_{dd}] = (1 + ig)[K_{dd}^1] + [K_{dd}^2] + i[K_{dd}^4],$$

$$[M_{dd}] = [M_{dd}^1] + [M_{dd}^2] \text{ and}$$

$$[B_{dd}] = [B_{dd}^1] + [B_{dd}^2].$$

Direct input matrices may be complex.

152. Equivalence $[K_{dd}^2]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input, $[M_{dd}^2]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[B_{dd}^2]$ to $[B_{dd}]$ if all damping is Direct Matrix Input.
154. Go to DMAP No. 183 and print error message if no Eigenvalue Extraction Data.
155. CEAD extracts complex eigenvalues from the equation
$$[M_{dd}p^2 + B_{dd}p + K_{dd}]\{u_d\} = 0$$
and normalizes eigenvectors according to one of the following user requests:
 - (1) Unit magnitude of selected coordinate
 - (2) Unit magnitude of largest component.
158. ØFP formats the summary of complex eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.
160. Go to DMAP No. 176 if no eigenvalues found.
161. VDR prepares eigenvectors for output, using only the independent degrees of freedom.
163. Go to DMAP No. 166 if no output request for the independent degrees of freedom.
164. ØFP formats the eigenvectors for independent degrees of freedom and places them on the system output file for printing.
167. Go to DMAP No. 176 if no output request involving dependent degrees of freedom or forces and stresses.
168. Equivalence $\{\phi_d\}$ to $\{\phi_p\}$ if no constraints applied.
169. Go to DMAP No. 171 if no constraints applied.

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170. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_d\} , \quad \begin{Bmatrix} \phi_d \\ -\phi_o \end{Bmatrix} = \{\phi_f + \phi_e\} ,$$

$$\begin{Bmatrix} \phi_f + \phi_e \\ \phi_s \end{Bmatrix} = \{\phi_n + \phi_e\} , \quad \{\phi_m\} = [G_m^d]\{\phi_n + \phi_e\} ,$$

$$\begin{Bmatrix} \phi_n + \phi_e \\ d_m \end{Bmatrix} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}^T]\{\phi_f\} .$$

173. SDR2 calculates element forces and stresses (ØEFC1, ØESC1) and prepares eigenvectors and single-point forces of constraint for output (ØCPHIP, ØQPC1).
174. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.
177. Go to DMAP No. 187 if no additional sets of direct input matrices need to be processed.
178. Go to DMAP No. 128 if additional sets of direct input matrices need to be processed.
179. Go to DMAP No. 181 and print error message if more than 100 loops.
180. Go to DMAP No. 187 and make normal exit.
182. DIRECT COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE NO. 2 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.
184. DIRECT COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE NO. 1 - EIGENVALUE EXTRACTION DATA REQUIRED FOR COMPLEX EIGENVALUE ANALYSIS.
186. DIRECT COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE NO. 3 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.

DIRECT COMPLEX EIGENVALUE ANALYSIS

3.8.3 Automatic Output for Direct Complex Eigenvalue Analysis

Each complex eigenvalue is identified with a root number determined by sorting the complex eigenvalues according to the magnitude of the imaginary part, with positive values considered as a group ahead of all negative values. The following summary of the complex eigenvalues extracted is automatically printed for each set of direct input matrices:

1. Root Number
2. Extraction Order
3. Real and Imaginary Parts of the Eigenvalue
4. The coefficients f_j (frequency) and g_j (damping coefficient) in the following representation of the eigenvalue

$$P_j = 2\pi f_j \left(i - \frac{1}{2} g_j \right)$$

The following summary of the eigenvalue analysis performed using the Determinant method is automatically printed for each set of direct input matrices:

1. Number of eigenvalues extracted
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Number of predictions outside region.
8. Reason for termination:
 - (1) The number of roots desired have been found.
 - (2) All predictions for eigenvalues are outside the regions specified.
 - (3) Insufficient time to find another root.
 - (4) Matrix is singular at first three starting points.
9. Swept determinant functions for each starting point.

RIGID FORMATS

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed for each region specified:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
 - (1) Two consecutive singularities encountered while performing triangular decomposition.
 - (2) Four starting point moves while tracking a single root.
 - (3) All eigenvalues found in the region specified.
 - (4) Three times the number of roots estimated in the region have been extracted.
 - (5) All eigenvalues that exist in the problem have been found.
 - (6) The number of roots desired have been found.
 - (7) One or more eigenvalues have been found outside the region specified.
 - (8) Insufficient time to find another root.
 - (9) Unable to converge.

3.8.4 Case Control Deck and Parameters for Direct Complex Eigenvalue Analysis

The following items relate to subcase definition and data selections for Direct Complex Eigenvalue Analysis.

1. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP).
2. Multiple subcases for each set of direct input matrices are used only to control output requests. A single subcase for each set of direct input matrices is sufficient if the same output is desired for all modes. If consecutive multiple subcases are present for a single set of direct input matrices, the output requests will be honored in succession for increasing mode numbers. MODES may be used to repeat subcases in order to make the same output request for several consecutive modes.

DIRECT COMPLEX EIGENVALUE ANALYSIS

3. CMETHØD must be used to select an EIGC card from the Bulk Data Deck for each set of direct input matrices.
4. On restart following an unscheduled exit due to insufficient time, the subcase structure must be changed to reflect the sets of direct input matrices that were completed, and either CMETHØD must be changed to select an EIGC card that reflects any complex eigenvalues found in the previous execution or EIGP cards must be used to insert poles for previously found eigenvalues. Otherwise, the previously found eigenvalues will be extracted again.
5. Constraints must be defined above the subcase level.

The following printed output, sorted by complex eigenvalue root number (SØRT1), may be requested for any complex eigenvalue extracted, as either real and imaginary parts or magnitude and phase angle (0° - 360° lead):

1. The eigenvector for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTION points (points used in formulation of the general K system).
2. Nonzero components of the single-point forces of constraint for a list of PHYSICAL points.
3. Stresses and forces in selected elements.

In addition an undeformed plot of the structural model may be requested.

The following parameters are used in Direct Complex Eigenvalue Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.
3. G - optional - the real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

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4. C0UPMASS - CPBAR, CPR0D, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

DIRECT FREQUENCY AND RANDOM RESPONSE

3.9 DIRECT FREQUENCY AND RANDOM RESPONSE

3.9.1 DMAP Sequence for Direct Frequency and Random Response

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 8

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NU.

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1 BEGIN      NU.8 DIRECT FREQUENCY RESPONSE ANALYSIS - SERIES N $
2 FILE       KGGX=TAPE/ KGG=TAPE/ GGD=SAVE/ GMD=SAVE $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/ V,N,
              NOGPDT $
4 SAVE       LUSET,NOGPDT $
5 PURGE      USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,
              GPSETS,ELSETS/NOGPDT $
6 CHKPNT     GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
              KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $
7 COND       LBL5,NOGPDT $
8 GP2        GEOM2,EQEXIN/ECT $
9 CHKPNT     ECT $
10 PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
11 PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
12 COND      P1,NOPCDB $
13 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
              JUMPPLOT=-1 $
14 SAVE      NSIL,JUMPPLOT $
15 PRMSG     PLTSETX// $
16 PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
17 PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
18 COND      P1,JUMPPLOT $
19 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
20 SAVE      PFILE $
21 PRMSG     PLOTX1// $
22 LABEL     P1 $
23 CHKPNT     PLTPAR,GPSETS,ELSETS $
24 GP3        GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $
25 CHKPNT     GPTT $

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RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

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NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NU.

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26 TAI      ECT,EPT,BCPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/  V,N,
           NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $

27 SAVE     NOSIMP,NOGENL,GENEL $

28 PURGE    K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA,
           KGGX/NOSIMP/OGPST/GENEL $

29 CHKPNT   EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,K4AA,
           MNN,MFF,MAA,BNN,BFF,BAA $

30 COND     LBL1,NOSIMP $

31 PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

32 PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

33 PARAM    //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $

34 PARAM    //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $

35 EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/  V,
           N,NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
           CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
           CPTRIA2/C,Y,CPTJBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

36 SAVE     NOKGGX,NOMGG,NOBGG,NOK4GG $

37 CHKPNT   KELM,KDICT,MELM,MDICT,BELM,BDICT $

38 COND     LBLKGGX,NOKGGX $

39 EMA      GPECT,KDICT,KELM/KGGX,GPST $

40 CHKPNT   KGGX,GPST $

41 LABEL    LBLKGGX $

42 COND     LBLMGG,NOMGG $

43 EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

44 CHKPNT   MGG $

45 LABEL    LBLMGG $

46 COND     LBLBGG,NOBGG $

47 EMA      GPECT,BDICT,BELM/BGG, $

48 CHKPNT   BGG $

49 LABEL    LBLBGG $

50 COND     LBLK4GG,NOK4GG $

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DIRECT FREQUENCY AND RANDOM RESPONSE

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51 EMA GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $
52 CHKPNT K4GG $
53 LABEL LBLK4GG $
54 PURGE MNN,MFF,MAA/NUMGG $
55 PURGE BNN,BFF,BAA/NUBGG $
56 CHKPNT MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $
57 COND LBL1,GRDPNT $
58 COND ERROR4,NUMGG $
59 GPWG BGPDT,CSTM,EQEXIN,MGG/UGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
60 OFP OGPWG,,,,,/$
61 LABEL LBL1 $
62 EQUIV KGGX,KGG/NOGENL $
63 CHKPNT KGG $
64 COND LBL11,NOGENL $
65 SMA3 GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
66 CHKPNT KGG $
67 LABEL LBL11 $
68 PARAM //C,N,MPY/V,N,NSKIP/C,N,O/C,N,O $
69 GP4 CASECC,GEOM4,EQEXIN,SIL,GPD, BGPDT,CSTM/RG,,USET,ASET/ V,N,
LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
70 SAVE MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NSKIP,REPEAT,NOL,NOA $
71 PURGE GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PSF,QPC/SINGLE $
72 CHKPNT GM,GMD,RG,GU,GOD,KFS,PSF,QPC,USET $
73 COND LBL4,GENEL $
74 COND LBL4,NOSIMP $
75 GPSP GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
76 SAVE NOGPST $
77 COND LBL4,NOGPST $

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RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 8

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

78	OFF	OGPST,,,,,// \$
79	LABEL	LBL4 \$
80	EQUIV	KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 \$
81	CHKPNT	KNN,MNN,BNN,K4NN \$
82	COND	LBL2,MPCF1 \$
83	MCE1	USET,RG/GM \$
84	CHKPNT	GM \$
85	MCE2	USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN \$
86	CHKPNT	KNN,MNN,BNN,K4NN \$
87	LABEL	LBL2 \$
88	EQUIV	KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE \$
89	CHKPNT	KFF,MFF,BFF,K4FF \$
90	COND	LBL3,SINGLE \$
91	SCE1	USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF \$
92	CHKPNT	KFS,KFF,MFF,BFF,K4FF \$
93	LABEL	LBL3 \$
94	EQUIV	KFF,KAA/OMIT \$
95	EQUIV	MFF,MAA/OMIT \$
96	EQUIV	BFF,BAA/OMIT \$
97	EQUIV	K4FF,K4AA/OMIT \$
98	CHKPNT	KAA,MAA,BAA,K4AA \$
99	COND	LBL5,OMIT \$
100	SMP1	USET,KFF,,,/GO,KAA,KOO,LOO,,,, \$
101	CHKPNT	GO,KAA \$
102	COND	LBLM,NOMGG \$
103	SMP2	USET,GO,MFF/MAA \$
104	CHKPNT	MAA \$
105	LABEL	LBLM \$

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RIGID FORMAT DMAP LISTING SERIES N

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

106	COND	LBLB,NU8GG \$
107	SMP2	USET,GO,BFF/BAA \$
108	CHKPNT	BAA \$
109	LABEL	LBLB \$
110	COND	LBL5,NUK4GG \$
111	SMP2	USET,GO,K4FF/K4AA \$
112	CHKPNT	K4AA \$
113	LABEL	LBL5 \$
114	DPD	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,,, EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NUDLT/V,N,NOPSDL/V,N, NOFRL/V,N,NOFL/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE \$
115	SAVE	LUSETD,NOUE,NUDLT,NOFRL,NOPSDL \$
116	EQUIV	GO,GOD/NOUE/GM,GMD/NOUE \$
117	CHKPNT	USETD,EQDYN,TFPOOL,DLT,FRL,GOD,GMD,SILD,PSDL,GPLD \$
118	PARAM	//C,N,ADD/V,N,NEVER/C,N,1/C,N,0 \$
119	PARAM	//C,N,MPY/V,N,REPEAT/C,N,-1/C,N,1 \$
120	BMG	MATPOOL,BGPD,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/V,N, MFACT \$
121	SAVE	MFACT,NOKBFL,NOABFL \$
122	PARAM	//C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL \$
123	PURGE	KBFL/NOKBFL/ ABFL/NOABFL \$
124	COND	LBLFL3,NOFL \$
125	MTRXIN	,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C, N,0 \$
126	SAVE	NOABFL,NOKBFL \$
127	LABEL	LBLFL3 \$
128	CHKPNT	ABFL,KBFL \$
129	PARAM	//C,N,MPY/V,N,CARDNU/C,N,0/C,N,0 \$
130	JUMP	LBL13 \$
131	LABEL	LBL13 \$

Top of DMAP Loop

RIGID FORMATS

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

132	PURGE	OUOVCI,OUOVC2,XYPLTFA,OPPC1,OQPC1,OUPVC1,DESC1,UEFC1,OPPC2, OQPC2,OUPVC2,DESC2,UEFC2,XYPLTF,PSDF,AUTO,XYPLTR, K2PP,M2PP, B2PP,K2DD,M2DD,B2DD/NEVER \$
133	CASE	CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATF/V,N,NOLoop \$
134	SAVE	REPEATF,NOLoop \$
135	CHKPNT	CASEXX \$
136	MTRXIN	CASEXX,MATPOOL,EQOYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N, NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP \$
137	SAVE	NOK2DPP,NOM2DPP,NOB2PP \$
138	PARAM	//C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP \$
139	PARAM	//C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP \$
140	EQUIV	M2DPP,M2PP/NOABFL \$
141	ADD5	ABFL,KBFL,K2DPP,,/K2PP/C,N,(-1.0,0.0) \$
142	COND	LBLFL2,NOABFL \$
143	TRNSP	ABFL/ABFLT \$
144	ADD	ABFLT,M2DPP/M2PP/V,N,MFACT \$
145	LABEL	LBLFL2 \$
146	PARAM	//C,N,AND/V,N,BDEBA/V,N,NOUE/V,N,NOB2PP \$
147	PARAM	//C,N,AND/V,N,KOEK2/V,N,NOGENL/V,N,NOSIMP \$
148	PARAM	//C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP \$
149	PURGE	K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP \$
150	EQUIV	M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/BAA, BDD/BDEBA \$
151	CHKPNT	K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,BDD,MDD \$
152	COND	LBL18,NOGPDOT \$
153	GKAD	USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD, GDD,K2DD,M2DD,B2DD/C,N,FREQRESP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/ C,N,0.0/C,N,0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/ V,N,MPCF1/ V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,KDEK2/C, N,-1 \$
154	LABEL	LBL18 \$
155	EQUIV	B2DD,BDD/NOBGG/ M2DD,MDD/NOSIMP/ K2DD,KDD/KDEK2 \$

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DMAP-DMAP INSTRUCTION
NO.

156	CHKPNT	KDD,BDD,MDD,GMD,GOD \$
157	COND	ERROR1,NOFRL \$
158	COND	ERROR2,NODLT \$
159	FRRD	CASEXX,USETD,DLT,FRL,GMD,GOD,KDD,BDD,MDD,,DIT/UDVF,PSF,PDF,PPF/ C,N,DISP/C,N,DIRECT/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/ V,N,NONCUP/V,N,FRQSET \$
160	EQUIV	PPF,PDF/NOSET \$
161	CHKPNT	PSF,PPF,UDVF,PDF \$
162	VDR	CASEXX,EQDYN,USETD,UDVF,PPF,XYCDB,/OUDVC1,/C,N,FREQRESP/C,N, DIRECT/V,N,NOSORT2/V,N,NOD/V,N,NOP/C,N,0 \$
163	SAVE	NOD,NOP,NOSORT2 \$
164	COND	LBL15,NOD \$
165	COND	LBL15A,NOSORT2 \$
166	CHKPNT	OUDVC1 \$
167	SDR3	OUDVC1,,,,,/OUDVC2,,,, \$
168	OFF	OUDVC2,,,,,/V,N,CARDNU \$
169	SAVE	CARDNU \$
170	CHKPNT	OUDVC2 \$
171	XYTRAN	XYCDB,OUDVC2,,,,/XYPLTFA/C,N,FREQ/C,N,DSET/V,N,PFILE/V,N, CARDNU \$
172	SAVE	PFILE,CARDNU \$
173	XYPLUT	XYPLTFA// \$
174	JUMP	LBL15 \$
175	LABEL	LBL15A \$
176	OFF	OUDVC1,,,,,/V,N,CARDNU \$
177	SAVE	CARDNU \$
178	LABEL	LBL15 \$
179	COND	LBL16,NOP \$
180	EQUIV	UDVF,UPVC/NOA \$
181	COND	LBL19,NOA \$

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
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NO.

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182 (SDR1)   USETD,,UDVF,,,GDD,GMD,PSF,KFS,,/UPVC,,QPC/C,N,1/C,N,DYNAMICS $
183 LABEL   LBL19 $
184 CHPNT   UPVC,QPC $
185 (SDR2)   CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,,PPF,QPC,UPVC,EST,XYCDB,PPF/
          OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/C,N,FREQRESP/V,N,NOSORT2 $
186 SAVE    NOSORT2 $
187 COND     LBL17,NOSORT2 $
188 (SDR3)   OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/OPPC2,OQPC2,OUPVC2,OESC2,
          OEFC2, $
189 CHPNT   OPPC2,OQPC2,OUPVC2,OESC2,OEFC2 $
190 OFP      OPPC2,OQPC2,OUPVC2,OEFC2,OESC2,//V,N,CARDNO $
191 SAVE     CARDNO $
192 (XYTRAN) XYCDB,OPPC2,OQPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
          V,N,PFILE/V,N,CARDNO $
193 SAVE     PFILE,CARDNO $
194 XYPLT     XYPLTF// $
195 COND     LBL16,NUPSDL $
196 (RANDOM)  XYCDB,DIT,PSDL,OUPVC2,OPPC2,OQPC2,OESC2,OEFC2,CASEXX/PSDF,AUTO/
          V,N,NORD $
197 SAVE     NORD $
198 CHPNT     PSDF,AUTO $
199 COND     LBL16,NORD $
200 (XYTRAN) XYCDB,PSDF,AUTO,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
          CARDNO $
201 SAVE     PFILE,CARDNO $
202 (XYPLOT) XYPLTR// $
203 JUMP      LBL16 $
204 LABEL     LBL17 $
205 OFP      OUPVC1,OPPC1,OQPC1,OEFC1,OESC1,//V,N,CARDNO $
206 SAVE     CARDNO $
207 LABEL     LBL16 $

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NO.

208	COND	FINIS, REPEATF \$
209	REPT	LBL13, 100 \$
210	JUMP	ERROR3 \$
211	JUMP	FINIS \$
212	LABEL	ERROR3 \$
213	PRTPARM	//C,N,-3/C,N,DIRFRD \$
214	LABEL	ERROR2 \$
215	PRTPARM	//C,N,-2/C,N,DIRFRD \$
216	LABEL	ERROR1 \$
217	PRTPARM	//C,N,-1/C,N,DIRFRD \$
218	LABEL	ERROR4 \$
219	PRTPARM	//C,N,-4/C,N,DIRFRD \$
220	LABEL	FINIS \$
221	END	\$

Bottom of DMAP Loop

RIGID FORMATS

3.9.2 Description of DMAP Operations for Direct Frequency and Random Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
7. Go to DMAP No. 113 if only Direct Matrix Input.
8. GP2 generates Element Connection Table with internal indices.
12. Go to DMAP No. 22 if no plot package is present.
13. PLTSET transforms user input into a form used to drive structure plotter.
15. PRTMSG prints error messages associated with structure plotter.
18. Go to DMAP No. 22 if no undeformed structure plot request.
19. PLØT generates all requested undeformed structure plots.
21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
24. GP3 generates Grid Point Temperature Table.
26. TAl generates element tables for use in matrix assembly and stress recovery.
30. Go to DMAP No. 61 if there are no structural elements.
35. EMG generates structural element matrix tables and dictionaries for later assembly.
38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.
39. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
42. Go to DMAP No. 45 if no mass matrix is to be assembled.
43. EMA assembles mass matrix $[M_{gg}]$.
46. Go to DMAP No. 49 if no viscous damping matrix.
47. EMA assembles viscous damping matrix $[B_{gg}]$.
50. Go to DMAP No. 53 if no structural damping matrix is to be assembled.
51. EMA assembles structural damping matrix $[K_{gg}^4]$.
57. Go to DMAP No. 61 if no weight and balance request.
58. Go to DMAP No. 218 and print error message if no mass matrix exists.
59. GPWG generates weight and balance information.
60. ØFP formats weight and balance information and places it on the system output file for printing.
62. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
64. Go to DMAP No. 67 if no general elements.
65. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.

DIRECT FREQUENCY AND RANDOM RESPONSE

69. GP4 generates flags defining members of various displacement sets (USET) and forms multi-point constraint equations $[R_g]\{u_g\} = 0$.
73. Go to DMAP No. 79 if general elements present.
74. Go to DMAP No. 79 if no structural elements.
75. GPSP determines if possible grid point singularities remain.
77. Go to DMAP No. 79 if no grid point singularities exist.
78. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.
80. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K_{gg}^4]$ to $[K_{nn}^4]$ if no multi-point constraints.
82. Go to DMAP No. 87 if MCE1 and MCE2 have already been executed for current set of multi-point constraints.
83. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
85. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right] , \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array} \right] ,$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array} \right] \quad \text{and} \quad [K_{gg}^4] = \left[\begin{array}{c|c} \bar{K}_{nn}^4 & K_{nm}^4 \\ \hline K_{mn}^4 & K_{mm}^4 \end{array} \right]$$

and performs matrix reductions

$$\begin{aligned} [K_{nn}] &= [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m], \\ [M_{nn}] &= [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m], \\ [B_{nn}] &= [\bar{B}_{nn}] + [G_m^T][B_{mn}] + [B_{mn}^T][G_m] + [G_m^T][B_{mm}][G_m], \\ [K_{nn}^4] &= [\bar{K}_{nn}^4] + [G_m^T][K_{mn}^4] + [K_{mn}^4]^T[G_m] + [G_m^T][K_{mm}^4][G_m]. \end{aligned}$$

88. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K_{nn}^4]$ to $[K_{ff}^4]$ if no single-point constraints.
90. Go to DMAP No. 93 if no single-point constraints.

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91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix}, \quad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix},$$

$$[B_{nn}] = \begin{bmatrix} B_{ff} & B_{fs} \\ B_{sf} & B_{ss} \end{bmatrix} \quad \text{and} \quad [K_{nn}^4] = \begin{bmatrix} K_{ff}^4 & K_{fs}^4 \\ K_{sf}^4 & K_{ss}^4 \end{bmatrix}.$$

94. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

95. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

96. Equivalence $[B_{ff}]$ to $[B_{aa}]$ if no omitted coordinates.

97. Equivalence $[K_{ff}^4]$ to $[K_{aa}^4]$ if no omitted coordinates.

99. Go to DMAP No. 113 if no omitted coordinates.

100. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \begin{bmatrix} K_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix}$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction

$$[K_{aa}^1] = [K_{aa}] + [K_{ao}][G_o].$$

102. Go to DMAP No. 105 if no mass matrix.

103. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} M_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}^1] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]$$

106. Go to DMAP No. 109 if no viscous damping matrix.

107. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \begin{bmatrix} B_{aa} & B_{ao} \\ B_{oa} & B_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[B_{aa}^1] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

DIRECT FREQUENCY AND RANDOM RESPONSE

110. Go to DMAP No. 113 if no structural damping matrix.

111. SMP2 partitions constrained structural damping matrix

$$[K_{ff}^4] = \left[\begin{array}{c|c} K_{aa}^4 & K_{ao}^4 \\ \hline K_{oa}^4 & K_{oo}^4 \end{array} \right]$$

and performs matrix reduction

$$[K_{aa}^4] = [K_{aa}^4] + [K_{ao}^4][G_o] + [K_{ao}^4 G_o]^T + [G_o^T][K_{oo}^4][G_o]$$

114. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Power Spectral Density List and Frequency Response List.

116. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

120. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

124. Go to DMAP No. 127 if no fluid structure interface is defined.

125. MTRXIN generates fluid boundary matrices $[A_{b,fl}]$ and $[K_{b,fl}]$ if a fluid structure interface is defined. The matrix $[K_{b,fl}]$ is generated only for a nonzero gravity in the fluid.

130. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

131. Beginning of loop for additional sets of direct input matrices.

133. CASE extracts user requests from CASECC for current loop.

136. MTRXIN selects the direct input matrices for the current loop, $[K_{pp}^{2d}]$, $[M_{pp}^{2d}]$ and $[B_{pp}^2]$.

140. Equivalence $[M_{pp}^{2d}]$ to $[M_{pp}^2]$ if no $[A_{b,fl}]$.

141. ADD5 adds $[K_{b,fl}]$ and $[K_{pp}^{2d}]$ and subtracts $[A_{b,fl}]$ from them to form $[K_{pp}^2]$.

142. Go to DMAP No. 145 if no $[A_{b,fl}]$.

143. Transpose $[A_{b,fl}]$ to obtain $[A_{b,fl}]^T$.

144. ADD assembles input matrix $[M_{pp}^2] = MFACT [A_{b,fl}]^T + [M_{pp}^{2d}]$.

150. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points and $[B_{aa}]$ to $[B_{dd}]$ if no direct input damping matrices and no extra points.

152. Go to DMAP No. 154 if only extra points defined.

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153. GKAD assembles stiffness, mass, and damping matrices for use in Direct Frequency Response

$$[K_{dd}] = (1 + ig)[K_{dd}^1] + [K_{dd}^2] + i[K_{dd}^4],$$

$$[M_{dd}] = [M_{dd}^1] + [M_{dd}^2] \text{ and}$$

$$[B_{dd}] = [B_{dd}^1] + [B_{dd}^2] .$$

Direct input matrices may be complex.

155. Equivalence $[K_{dd}^2]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input, $[M_{dd}^2]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[B_{dd}^2]$ to $[B_{dd}]$ if all damping is Direct Matrix Input.
157. Go to DMAP No. 216 and print error message if no Frequency Response List.
158. Go to DMAP No. 214 and print error message if no Dynamics Load Table.
159. FRRD forms the dynamic load vectors $\{P_d\}$ and solves for the displacements using the following equation

$$[-M_{dd}\omega^2 + iB_{dd}\omega + K_{dd}]\{u_d\} = \{P_d\} .$$

160. Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.
162. VDR prepares displacements, sorted by frequency, for output using only the independent degrees of freedom.
164. Go to DMAP No. 178 if no output request for the independent degrees of freedom.
165. Go to DMAP No. 175 if no output request for independent displacements sorted by point number.
167. SDR3 sorts the independent displacements by point number.
168. ØFP formats the requested independent displacements sorted by point number and places them on the system output file for printing.
171. XYTRAN prepares the input for X-Y plotting of the independent displacements vs. frequency.
173. XYPLØT prepares the requested X-Y plots of the independent displacements vs. frequency.
176. ØFP formats the requested independent displacements sorted by frequency and places them on the system output file for printing.
179. Go to DMAP No. 207 if no output request involving dependent degrees of freedom or forces and stresses.
180. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.
181. Go to DMAP No. 183 if no constraints applied.

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182. SDR1 recovers dependent components of displacements

$$\begin{aligned} \{u_o\} &= [G_o^d] \{u_d\} \quad , & \begin{Bmatrix} u_d \\ u_o \end{Bmatrix} &= \{u_f + u_e\} \quad , \\ \begin{Bmatrix} u_f + u_e \\ u_s \end{Bmatrix} &= \{u_n + u_e\} \quad , & \{u_m\} &= [G_m^d] \{u_f + u_e\} \quad , \\ \begin{Bmatrix} u_n + u_e \\ u_m \end{Bmatrix} &= \{u_p\} \end{aligned}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T] \{u_f\}$.

185. SDR2 calculates element forces and stresses ($\emptyset EFC1$, $\emptyset ESC1$) and prepares load vectors, displacement vectors and single-point forces of constraint for output ($\emptyset PPC1$, $\emptyset UPVC1$, $\emptyset QPC1$) - all sorted by frequency.
187. Go to DMAP No. 204 if no output requests sorted by point number or element number.
188. SDR3 prepares requested output sorted by point number or element number.
190. $\emptyset FP$ formats the requested output sorted by point number or element number and places it on the system output file for printing.
192. XYTRAN prepares the input for requested X-Y plots.
194. XYPL $\emptyset T$ prepares the requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.
195. Go to DMAP No. 207 if no Power Spectral Density List.
196. RAND $\emptyset M$ calculates power spectral density functions and autocorrelation functions using the previously calculated frequency response.
199. Go to DMAP No. 207 if no RAND $\emptyset M$ calculations requested.
200. XYTRAN prepares the input for requested X-Y plots of the RAND $\emptyset M$ output. -
202. XYPL $\emptyset T$ prepares the requested X-Y plots of autocorrelation functions and power spectral density functions.
203. Go to DMAP No. 207 if no frequency response output requests sorted by frequency.
205. $\emptyset FP$ formats frequency response output requests sorted by frequency and places them on the system output file for printing.
208. Go to DMAP No. 220 if no additional sets of direct input matrices need to be processed.
209. Go to DMAP No. 131 if additional sets of direct input matrices need to be processed.
210. Go to DMAP No. 212 and print error message if more than 100 loops.
211. Go to DMAP No. 220 and make normal exit.

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- 213. DIRECT FREQUENCY AND RANDOM RESPONSE ERROR MESSAGE NO. 3 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.
- 215. DIRECT FREQUENCY AND RANDOM RESPONSE ERROR MESSAGE NO. 2 - DYNAMIC LOADS TABLE REQUIRED FOR FREQUENCY RESPONSE CALCULATIONS.
- 217. DIRECT FREQUENCY AND RANDOM RESPONSE ERROR MESSAGE NO. 1 - FREQUENCY RESPONSE LIST REQUIRED FOR FREQUENCY RESPONSE CALCULATIONS.
- 219. DIRECT FREQUENCY AND RANDOM RESPONSE ERROR MESSAGE NO. 4 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.

DIRECT FREQUENCY AND RANDOM RESPONSE

3.9.3 Case Control Deck and Parameters for Direct Frequency and Random Response

The following items relate to subcase definition and data selection for Direct Frequency and Random Response:

1. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP) or frequencies.
2. Consecutive subcases for each set of direct input matrices or frequencies are used to define the loading conditions - one subcase for each dynamic loading condition.
3. Constraints must be defined above the subcase level.
4. DL0AD must be used to define a frequency-dependent loading condition for each subcase.
5. FREQUENCY must be used to select one, and only one, FREQ, FREQ1, or FREQ2 card from the Bulk Data Deck for each unique set of direct input matrices.
6. On restart following an unscheduled exit due to insufficient time, the subcase structure must be changed to reflect the sets of direct input matrices that were completed, and FREQUENCY must be changed to select a FREQ, FREQ1, or FREQ2 card that reflects any frequencies for which the response has already been determined. Otherwise the previous calculations will be repeated.
7. 0FREQUENCY may be used above the subcase level or within each subcase to select a subset of the solution frequencies for output requests. The default is to use all solution frequencies.
8. If Random Response calculations are desired, RAND0M must be used to select RANDPS and RANDTi cards from the Bulk Data Deck. Only one 0FREQUENCY and FREQUENCY card can be used for each set of direct input matrices.

The following printed output, sorted by frequency (S0RT1) or by point number or element number (S0RT2), is available, either as real and imaginary parts or magnitude and phase angle (0° - 360° lead), for the list of frequencies specified by 0FREQUENCY:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or S0LUTI0N points (points used in formulation of the general K system).

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2. Nonzero components of the applied load vector and single-point forces of constraint for a list of PHYSICAL points.
3. Stresses and forces in selected elements (ALL available only for SØRT1).

The following plotter output is available for Frequency Response calculations:

1. Undeformed plot of the structural model.
2. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTION point.
3. X-Y plot of any component of the applied load vector or single-point force of constraint.
4. X-Y plot of any stress or force component for an element.

The following plotter output is available for Random Response calculations:

1. X-Y plot of the power spectral density versus frequency for the response of selected components for points or elements.
2. X-Y plot of the autocorrelation versus time lag for the response of selected components for points or elements.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.3). This is the only form of printed output that is available for Random Response. Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Frequency Response calculations:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.

DIRECT FREQUENCY AND RANDOM RESPONSE

3. G - optional - the real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.
4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

DIRECT TRANSIENT RESPONSE

3.10 DIRECT TRANSIENT RESPONSE

3.10.1 DMAP Sequence for Direct Transient Response

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 9

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

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1 BEGIN      NO.9 DIRECT TRANSIENT RESPONSE ANALYSIS - SERIES N $
2 FILE       KGGX=TAPE/ KGG=TAPE/ UDV=APPEND $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPD,T,CSTM,BGPDT,SIL/V,N,LUSET/ V,N,
              NOGPD $
4 SAVE       LUSET,NOGPD $
5 PURGE      USET,GM,GO,KAA,BAA,MAA,K4AA,PST,KFS,QP,EST,ECT,PLTSETX,PLTPAR,
              GPSETS,ELSETS/NOGPD $
6 CHKPNT     GPL,EQEXIN,GPD,T,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
              PST,KFS,QP,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $
7 COND       LBL5,NOGPD $
8 GP2        GEOM2,EQEXIN/ECT $
9 CHKPNT     ECT $
10 PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
11 PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
12 COND      P1,NOPCDB $
13 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
              JUMPPLOT=-1 $
14 SAVE      NSIL,JUMPPLOT $
15 PRMSG     PLTSETX// $
16 PARAM      //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
17 PARAM      //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
18 COND      P1,JUMPPLOT $
19 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
20 SAVE      JUMPPLOT,PLTFLG,PFILE $
21 PRMSG     PLUTX1// $
22 LABEL     P1 $
23 CHKPNT     PLTPAR,GPSETS,ELSETS $
24 GP3        GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $
25 CHKPNT     SLT,GPTT $

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NU.

26	TAL	ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N, NUSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL \$
27	SAVE	NOSIMP,NOGENL,GENEL \$
28	PURGE	K4GG,GPST,OGPST,MGG,BGG, K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF, BAA,KGGX/NUSIMP/ OGPST/GENEL \$
29	CHKPNT	EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST, K4NN,K4FF,K4AA, MNN,MFF,MAA,BNN,BFF,BAA \$
30	COND	L8L1,NOSIMP \$
31	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
32	PARAM	//C,N,ADD/V,N,NUMGG/C,N,1/C,N,0 \$
33	PARAM	//C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 \$
34	PARAM	//C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 \$
35	EMG	EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/ V, N,NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y, CPBAR/C,Y,CPRD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y, CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
36	SAVE	NOKGGX,NUMGG,NOBGG,NOK4GG \$
37	CHKPNT	KELM,KDICT,MELM,MDICT,BELM,BDICT \$
38	COND	L8LKGGX,NOKGGX \$
39	EMA	GPECT,KDICT,KELM/KGGX,GPST \$
40	CHKPNT	KGGX,GPST \$
41	LABEL	L8LKGGX \$
42	COND	L8LMGG,NUMGG \$
43	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
44	CHKPNT	MGG \$
45	LABEL	L8LMGG \$
46	COND	L8LBGG,NOBGG \$
47	EMA	GPECT,BDICT,BELM/BGG, \$
48	CHKPNT	BGG \$
49	LABEL	L8LBGG \$
50	COND	L8LK4GG,NOK4GG \$

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51	EMA	GPECT,KDICT,KELM/K4GG,/V,N,NUK4GG \$
52	CHKPNT	K4GG \$
53	LABEL	LBLK4GG \$
54	PURGE	MNN,MFF,MAA/NOMGG \$
55	PURGE	BNN,BFF,BAA/NUBGG \$
56	CHKPNT	MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA \$
57	COND	LBL1,GRDPNT \$
58	COND	ERROR3,NUMGG \$
59	GPWG	BGPD,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS \$
60	DFP	OGPWG,,,,,// \$
61	LABEL	LBL1 \$
62	EQUIV	KGGX,KGG/NOGENL \$
63	CHKPNT	KGG \$
64	COND	LBL11,NOGENL \$
65	SMA3	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$
66	CHKPNT	KGG \$
67	LABEL	LBL11 \$
68	PARAM	//C,N,MPY/V,N,NSKIP/C,N,O/C,N,O \$
69	GP4	CASECC,GEUM4,EQEXIN,SIL,GPD,CST/RG,,USET,ASET/ V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NUSET/V,N,NUL/V,N,NOA/C,Y,SUBID \$
70	SAVE	MPCF1,SINGLE,OMIT,NUSET,REACT,MPCF2,NSKIP,REPEAT,NUL,NOA \$
71	PURGE	GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST,QP/SINGLE \$
72	CHKPNT	GM,GMD,RG,GO,GOD,KFS,PST,QP,USET \$
73	COND	LBL4,GENEL \$
74	COND	LBL4,NOSIMP \$
75	GPSP	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
76	SAVE	NOGPST \$
77	COND	LBL4,NOGPST \$

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

78	UFP	OGPST,,,,,// \$
79	LABEL	LBL4 \$
80	EQUIV	KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 \$
81	CHKPNT	KNN,MNN,BNN,K4NN \$
82	COND	LBL2,MPCF1 \$
83	<u>MCE1</u>	USET,KG/GM \$
84	CHKPNT	GM \$
85	<u>MCE2</u>	USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN \$
86	CHKPNT	KNN,MNN,BNN,K4NN \$
87	LABEL	LBL2 \$
88	EQUIV	KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE \$
89	CHKPNT	KFF,MFF,BFF,K4FF \$
90	COND	LBL3,SINGLE \$
91	<u>SCE1</u>	USET,KNN,MNN,BNN,K4NN/KFF,KFS, ,MFF,BFF,K4FF \$
92	CHKPNT	KFS,KFF,MFF,BFF,K4FF \$
93	LABEL	LBL3 \$
94	EQUIV	KFF,KAA/OMIT \$
95	EQUIV	MFF,MAA/OMIT \$
96	EQUIV	BFF,BAA/OMIT \$
97	EQUIV	K4FF,K4AA/OMIT \$
98	CHKPNT	KAA,MAA,BAA,K4AA \$
99	COND	LBL5,OMIT \$
100	<u>SMP1</u>	USET,KFF,,,/GO,KAA,KUD,LOO,,,,, \$
101	CHKPNT	GO,KAA \$
102	COND	LBLM,NUMGG \$
103	<u>SMP2</u>	USET,GO,MFF/MAA \$
104	CHKPNT	MAA \$
105	LABEL	LBLM \$

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106 COND      LBL8,NU8GG $
107 SMP2      USET,GO,BFF/BAA $
108 CHKPNT    BAA $
109 LABEL     LBL8 $
110 COND      LBL5,NUK4GG $
111 SMP2      USET,GO,K4FF/K4AA $
112 CHKPNT    K4AA $
113 LABEL     LBL5 $
114 DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL,,
EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NUPSDL/V,
N,NUFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
115 SAVE      LUSETD,NODLT,NONLFT,NOTRL,NOUE $
116 PURGE     PNLD/NONLFT$
117 EQUIV     GO,GOD/NOUE/GM,GMD/NOUE $
118 CHKPNT    USETD,EQDYN,TFPOOL,DLT,TRL,GOD,GMD,NLFT,PNLD,SILD,GPLD $
119 BMG       MATPOOL,BOPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/V,N,
MFACT $
120 SAVE      MFACT,NOKBFL,NOABFL $
121 PARAM     //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $
122 PURGE     KBFL/NUKBFL/ ABFL/NOABFL $
123 COND      LBLFL3,NOFL $
124 MTRXIN    ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
N,O $
125 SAVE      NOABFL,NOKBFL $
126 LABEL     LBLFL3 $
127 CHKPNT    ABFL,KBFL $
128 MTRXIN    CASECC,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
NUK2DPP/V,N,NOM2DPP/V,N,NUB2PP $
129 SAVE      NUK2DPP,NOM2DPP,NUB2PP $
130 PARAM     //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $
131 PARAM     //C,N,AND/V,N,NOK2PP/V,N,NOFL/V,N,NUK2DPP $

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

132	EQUIV	M2DPP,M2PP/NOABFL \$
133	ADD5	ABFL,KBFL,K2DPP,,/K2PP/C,N,(-1.0,0.0) \$
134	COND	LBLFL2,NOABFL \$
135	TRNSP	ABFL/ABFLT \$
136	ADD	ABFLT,M2DPP/M2PP/V,N,MFACT \$
137	LABEL	LBLFL2 \$
138	PARAM	//C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NOK2PP \$
139	PARAM	//C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP \$
140	PARAM	//C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP \$
141	PURGE	K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP \$
142	EQUIV	M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/ KAA, KDD/KDEKA \$
143	CHKPNT	K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD,KDD \$
144	COND	LBL16,NOGPDT \$
145	GKAD	USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD, GUD,K2DD,M2DD,B2DD/C,N,TRANRESP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/ C,Y,W3=0.0/C,Y,W4=0.0/V,N,NOK2PP/V,N,NUM2PP/V,N,NOB2PP/ V,N, MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N, KDEK2/C,N,-1 \$
146	LABEL	LBL16 \$
147	EQUIV	M2DD,MDD/NOSIMP/B2DD,BDD/NOGPDT/K2DD,KDD/KDEK2 \$
148	CHKPNT	KDD,BDD,MDD,GMD,GDD \$
149	COND	ERROR1,NOTRL \$
150	PARAM	//C,N,ADD/V,N,NEVER/C,N,1/C,N,0 \$
151	PARAM	//C,N,MPY/V,N,REPEAT/C,N,1/C,N,-1 \$
152	PARAM	//C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 \$
153	JUMP	LBL13 \$
154	LABEL	LBL13 \$
155	PURGE	PNLD,QUOV1,OPNL1,QUOV2,OPNL2,XYPLTTA,OPP1,OQP1,OUPV1,OES1,DEF1, OPP2,OQP2,OUPV2,CES2,DEF2,PLOTX2,XYPLTT/NEVER \$
156	CASE	CASECC,/CASEXX/C,N,TRAN/V,N,REPEAT/V,N,NOLoop \$

Top of DMAP Loop

DIRECT TRANSIENT RESPONSE

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 9

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

157	SAVE	REPEAT,NOLOOP \$
158	CHKPNT	CASEXX \$
159	PARAM	//C,N,MPY/V,N,NCOL/C,N,O/C,N,1 \$
160	TRLG	CASEXX,USED,DLT,SLT,BGPDT,SIL,CSTM,TRL,DIT,GMD,GOD,,EST,MGG/ PPT,PST,PDT,PD,,TOL/V,N,NOSET/V,N,PDEPDO/V,N,NCOL \$
161	SAVE	PDEPDO,NUSET \$
162	CHKPNT	PPT,PST,PDT,PD,TOL \$
163	EQUIV	PD,PDT/PDEPDO/PPT,PDT/NOSET \$
164	CHKPNT	PDT \$
165	TRD	CASEXX,TRL,NLFT,DIT,KDD,BDD,MDD,PD/UDVT,PNLD/C,N,DIRECT/V,N, NUUE/V,N,NONCUP/V,N,NCOL \$
166	SAVE	NCOL \$
167	CHKPNT	UDVT,PNLD \$
168	VDR	CASEXX,EQDYN,USED,UDVT,TOL,XYCDB,PNLD/UDV1,OPNL1/ C,N, TRANRESP/C,N,DIRECT/C,N,O/V,N,NOD/V,N,NOP/C,N,O \$
169	SAVE	NOD,NOP \$
170	CHKPNT	UDV1,OPNL1 \$
171	COND	LBL15,NOD \$
172	SDR3	UDV1,OPNL1,,,/UDV2,OPNL2,,, \$
173	DFP	UDV2,OPNL2,,,//V,N,CARDNU \$
174	SAVE	CARDNU \$
175	CHKPNT	OPNL2,UDV2 \$
176	XYTRAN	XYCDB,UDV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,DSET/V,N,PFILE/V,N, CARDNU \$
177	SAVE	PFILE,CARDNU \$
178	XYPLOT	XYPLTTA// \$
179	LABEL	LBL15 \$
180	PARAM	//C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT \$
181	CUND	LBL18,PJUMP \$
182	EQUIV	UDVT,UPV/NOA \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 9

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

183	COND	LBL17,NOA \$
184	SDR1	USED,UDVT,,,GDD,GMD,PST,KFS,,/UPV,,QP/C,N,1/C,N,DYNAMICS \$
185	LABEL	LBL17 \$
186	CHKPNT	UPV,QP \$
187	SDR2	CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPD,TOL,QP,UPV,EST,XYCDB, PPT/OPP1,OQP1,OUPV1,OES1,DEF1,PUGV/C,N,TRANRESP \$
188	SDR3	OPP1,OQP1,OUPV1,OES1,DEF1,/OPP2,OQP2,OUPV2,OES2,DEF2, \$
189	CHKPNT	OPP2,OQP2,OUPV2,OES2,DEF2 \$
190	DFP	OPP2,OQP2,OUPV2,DEF2,OES2,//V,N,CARDNO \$
191	SAVE	CARDNO \$
192	COND	P2,JUMPPLOT \$
193	PLOT	PLTPAR,GPSETS,ELSETS,CASEXX,BGPD,EQEXIN,SIL,,PUGV,GPECT,OES1/ PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
194	SAVE	PFILE \$
195	PRTMSG	PLOTX2// \$
196	LABEL	P2 \$
197	XYTRAN	XYCDB,OPP2,OQP2,OUPV2,OES2,DEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N, PFILE/V,N,CARDNO \$
198	SAVE	PFILE,CARDNO \$
199	XYPLOT	XYPLTT// \$
200	LABEL	LBL18 \$
201	COND	FINIS,REPEAT \$
202	REPT	LBL13,100 \$
203	JUMP	ERROR2 \$
204	JUMP	FINIS \$
205	LABEL	ERROR2 \$
206	PRTPARM	//C,N,-2/C,N,DIRTRD \$
207	LABEL	ERROR1 \$
208	PRTPARM	//C,N,-1/C,N,DIRTRD \$
209	LABEL	ERROR3 \$

Bottom of DMAP Loop

DIRECT TRANSIENT RESPONSE

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

210 PRTPARM //C,N,-3/C,N,DIRTRD \$

211 LABEL FINIS \$

212 END \$

RIGID FORMATS

3.10.2 Description of DMAP Operations for Direct Transient Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
7. Go to DMAP No. 113 if only Direct Matrix Input.
8. GP2 generates Element Connection Table with internal indices.
12. Go to DMAP No. 22 if no plot package is present.
13. PLTSET transforms user input into a form used to drive structure plotter.
15. PRTMSG prints error messages associated with structure plotter.
18. Go to DMAP No. 22 if no undeformed structure plot request.
19. PLØT generates all requested undeformed structure plots.
21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
24. GP3 generates Grid Point Temperature Table.
26. TAl generates element tables for use in matrix assembly and stress recovery.
30. Go to DMAP No. 61 if there are no structural elements.
35. EMG generates structural element matrix tables and dictionaries for later assembly.
38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.
39. EMA assembles stiffness matrix $[K_{gg}^X]$ and Grid Point Singularity Table.
42. Go to DMAP No. 45 if no mass matrix is to be assembled.
43. EMA assembles mass matrix $[M_{gg}]$.
46. Go to DMAP No. 49 if no viscous damping matrix.
47. EMA assembles viscous damping matrix $[B_{gg}]$.
50. Go to DMAP No. 53 if no structural damping matrix.
51. EMA assembles structural damping matrix $[K_{gg}^4]$.
57. Go to DMAP No. 61 if no weight and balance request.
58. Go to DMAP No. 209 and print error message if no mass matrix exists.
59. GPWG generates weight and balance information.
60. ØFP formats weight and balance information and places it on the system output file for printing.
62. Equivalence $[K_{gg}^X]$ to $[K_{gg}]$ if no general elements.
64. Go to DMAP No. 67 if no general elements.
65. SMA3 adds general elements to $[K_{gg}^X]$ to obtain stiffness matrix $[K_{gg}]$.
69. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.
73. Go to DMAP No. 79 if general elements present.
74. Go to DMAP No. 79 if no structural elements.

DIRECT TRANSIENT RESPONSE

75. GPSP determines if possible grid point singularities remain.
77. Go to DMAP No. 79 if no grid point singularities exist.
78. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.
80. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K_{gg}^4]$ to $[K_{nn}^4]$ if no multipoint constraints.
82. Go to DMAP No. 87 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
83. MCE1 partitions multipoint constraint equations $[R_g] = [R_m; R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
85. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right], \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array} \right],$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array} \right] \quad \text{and} \quad [K_{gg}^4] = \left[\begin{array}{c|c} \bar{K}_{nn}^4 & K_{nm}^4 \\ \hline K_{mn}^4 & K_{mm}^4 \end{array} \right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G_m^T][B_{mn}] + [B_{mn}^T][G_m] + [G_m^T][B_{mm}][G_m],$$

$$[K_{nn}^4] = [\bar{K}_{nn}^4] + [G_m^T][K_{mn}^4] + [K_{mn}^4]^T[G_m] + [G_m^T][K_{mm}^4][G_m].$$

88. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K_{nn}^4]$ to $[K_{ff}^4]$ if no single-point constraints.
90. Go to DMAP No. 93 if no single-point constraints.
91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array} \right], \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array} \right],$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array} \right] \quad \text{and} \quad [K_{nn}^4] = \left[\begin{array}{c|c} K_{ff}^4 & K_{fs}^4 \\ \hline K_{sf}^4 & K_{ss}^4 \end{array} \right].$$

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94. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.
95. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.
96. Equivalence $[B_{ff}]$ to $[B_{aa}]$ if no omitted coordinates.
97. Equivalence $[K_{ff}^4]$ to $[K_{aa}^4]$ if no omitted coordinates.
99. Go to DMAP No. 113 if no omitted coordinates.
100. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right]$$

solves for transformation matrix $[G_o] = [K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction

$$[K_{aa}^1] = [K_{aa}] + [K_{ao}][G_o]$$

102. Go to DMAP No. 105 if no mass matrix.

103. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array} \right]$$

and performs matrix reduction

$$[M_{aa}^1] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]$$

106. Go to DMAP No. 109 if no viscous damping matrix.

107. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array} \right]$$

and performs matrix reduction

$$[B_{aa}^1] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

110. Go to DMAP No. 113 if no structural damping matrix.

111. SMP2 partitions constrained structural damping matrix

$$[K_{ff}^4] = \left[\begin{array}{c|c} K_{aa}^4 & K_{ao}^4 \\ \hline K_{oa}^4 & K_{oo}^4 \end{array} \right]$$

and performs matrix reduction

$$[K_{aa}^4] = [K_{aa}^4] + [K_{ao}^4][G_o] + [K_{ao}^4G_o]^T + [G_o^T][K_{oo}^4][G_o]$$

DIRECT TRANSIENT RESPONSE

114. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Nonlinear Function Table and Transient Response List..
117. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.
119. BMG generates DMIG card images describing the interconnection of the fluid and the structure.
123. Go to DMAP No. 126 if no fluid structure interface is defined.
124. MTRXIN generates fluid boundary matrices $[A_{b,fl}]$ and $[K_{b,fl}]$ if a fluid structure interface is defined. The matrix $[K_{b,fl}]$ is generated only for a nonzero gravity in the field.
128. MTRXIN selects the direct input matrices $[K_{pp}^{2d}]$, $[M_{pp}^{2d}]$ and $[B_{pp}^2]$.
132. Equivalence $[M_{pp}^{2d}]$ to $[M_{pp}^2]$ if no $[A_{b,fl}]$.
133. ADD5 adds $[K_{b,fl}]$ and $[K_{pp}^{2d}]$ and subtracts $[A_{b,fl}]$ from them to form $[K_{pp}^2]$.
134. Go to DMAP No. 137 if no $[A_{b,fl}]$.
135. Transpose $[A_{b,fl}]$ to obtain $[A_{b,fl}]^T$.
136. ADD assembles input matrix $[M_{pp}^2] = \text{MFACT } [A_{b,fl}]^T + [M_{pp}^{2d}]$.
142. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[K_{aa}]$ to $[K_{dd}]$ if no direct input stiffness matrices and no extra points.
144. Go to DMAP No. 146 if only extra points defined.
145. GKAD assembles stiffness, mass, and damping matrices for use in Direct Transient Response

$$\begin{aligned} [K_{dd}] &= [K_{dd}^1] + [K_{dd}^2], \\ [M_{dd}] &= [M_{dd}^1] + [M_{dd}^2] \text{ and} \\ [B_{dd}] &= [B_{dd}^1] + [B_{dd}^2] + \frac{g}{\omega_3} [K_{dd}^1] + \frac{1}{\omega_4} [K_{dd}^4]. \end{aligned}$$

All matrices are real.

147. Equivalence $[B_{dd}^2]$ to $[B_{dd}]$ if all damping is Direct Matrix Input, $[M_{dd}^2]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[K_{dd}^2]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input.
149. Go to DMAP No.207 and print error message if no Transient Response List.
153. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.
154. Beginning of loop for additional dynamic load sets.
156. CASE extracts user requests from CASECC for current loop.

RIGID FORMATS

160. TRLG generates matrices of loads versus time. $\{P_p^t\}$, $\{P_s^t\}$, and $\{P_d^t\}$ are generated with one column per output time step. $\{P_d\}$ is generated with one column per solution time step, and the Transient Output List (TOL) is a list of output time steps.
163. Equivalence $\{P_d\}$ to $\{P_d^t\}$ if the output times are the same as the solution times and $\{P_p^t\}$ to $\{p_d^t\}$ if the d and p sets are the same.
165. TRD forms the linear and nonlinear dynamic load vectors $\{P_d\}$ and $\{P_d^{nl}\}$ and integrates the equations of motion over specified time periods to solve for the displacements, velocities, and accelerations, using the following equation

$$[M_{dd}p^2 + B_{dd}p + K_{dd}]\{u_d\} = \{P_d\} + \{P_d^{nl}\}.$$

168. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the independent degrees of freedom.
171. Go to DMAP No. 179 if no output request for the independent degrees of freedom.
172. SDR3 sorts the independent displacements, velocities, accelerations and nonlinear load vectors by point number.
173. ØFP formats the requested independent displacements, velocities, accelerations and nonlinear load vectors sorted by point number and places them on the system output file for printing.
176. XYTRAN prepares the input for X-Y plotting of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.
178. XYPLØT prepares requested X-Y plots of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.
181. Go to DMAP No. 200 if no output request involving dependent degrees of freedom or forces and stresses.
182. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.
183. Go to DMAP No. 185 if no constraints applied.
184. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\}, \quad \begin{pmatrix} u_d \\ - \\ u_o \end{pmatrix} = \{u_f + u_e\},$$

$$\begin{pmatrix} u_f + u_e \\ - \\ u_s \end{pmatrix} = \{u_n + u_e\}, \quad \{u_m\} = [G_m^d]\{u_f + u_e\},$$

$$\begin{pmatrix} u_n + u_e \\ - \\ u_m \end{pmatrix} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

187. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement, velocity and acceleration vectors and single-point forces of constraint for output (ØPPI, ØUPV1, PUGV, ØQPI) - all sorted by time step.
188. SDR3 prepares requested output sorted by point number or element number.

DIRECT TRANSIENT RESPONSE

190. ØFP formats requested output sorted by point number or element number and places it on the system output file for printing.
192. Go to DMAP No. 196 if no deformed structure plots requested.
193. PLØT prepares all requested deformed structure plots.
195. PRTMSG prints plotter data and engineering data for each deformed plot generated.
197. XYTRAN prepares the input for requested X-Y plots.
199. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs. time.
201. Go to DMAP No. 211 if no additional dynamic load sets need to be processed.
202. Go to DMAP No. 154 if additional dynamic load sets need to be processed.
203. Go to DMAP No. 205 and print error message if more than 100 loops.
204. Go to DMAP No. 211 and make normal exit.
206. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.
208. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.
210. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.10.3 Case Control Deck and Parameters for Direct Transient Response

The following items relate to subcase definition and data selection for Direct Transient Response:

1. One subcase must be defined for each dynamic loading condition.
2. DL0AD or N0NLINER must be used to define a time-dependent loading condition for each subcase.
3. Constraints must be defined above the subcase level.
4. TSTEP must be used to select the time-step intervals to be used for integration and output in each subcase.
5. If nonzero initial conditions are desired, IC must be used to select a TIC card in the Bulk Data Deck.
6. On restart following an unscheduled exit due to insufficient time, the subcase structure should be changed to reflect any completed loading conditions. The TSTEP selections must be changed if it is desired to resume the integration at the point terminated.

The following printed output, sorted by point number or element number (S0RT2) is available at selected multiples of the integration time step:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or S0LUTI0N points (points used in formulation of the general K system).
2. Nonzero components of the applied load vector and single point forces of constraint for a list of PHYSICAL points.
3. Nonlinear force vector for a list of S0LUTI0N points.
4. Stresses and forces in selected elements (All not allowed).

The following plotter output is available for Transient Response:

1. Undeformed plot of the structural model.
2. Deformed shapes of the structural model for selected time intervals.
3. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or S0LUTI0N point.

DIRECT TRANSIENT RESPONSE

4. X-Y plot of any component of the applied load vector, nonlinear force vector, or single-point force of constraint.
5. X-Y plot of any stress or force component for an element.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Direct Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.
3. G - optional - The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.
4. W3 and W4 - optional - The values of these parameters are used as pivotal frequencies for uniform structural damping and element structural damping respectively. W3 is required if uniform structural damping is desired. W4 is required if structural damping is desired for any of the structural elements. See page 9.3-8 of the NASTRAN Theoretical Manual.
5. COUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

MODAL COMPLEX EIGENVALUE ANALYSIS

3.11 MODAL COMPLEX EIGENVALUE ANALYSIS

3.11.1 DMAP Sequence for Modal Complex Eigenvalue Analysis

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NO.10 MODAL COMPLEX EIGENVALUE ANALYSIS - SERIES N $
2 FILE       GOD=SAVE/ GMD=SAVE/ LAMA=APPEND/ PHIA=APPEND $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPD,SIL/V,N,LUSET/ V,N,
              NUGPD $
4 SAVE       LUSET $
5 CHKPNT     GPL,EQEXIN,GPDT,CSTM,BGPD,SIL $
6 GP2        GEOM2,EQEXIN/ECT $
7 CHKPNT     ECT $
8 PARAML     PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
9 PURGE      PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
10 COND      P1,NOPCDB $
11 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
              JUMPPLOT=-1 $
12 SAVE      NSIL,JUMPPLOT $
13 PRTMSG     PLTSETX// $
14 PARAM      //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
15 PARAM      //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
16 COND      P1,JUMPPLOT $
17 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPD,EQEXIN,SIL,,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
18 SAVE      PFILE $
19 PRTMSG     PLUTX1// $
20 LABEL     P1 $
21 CHKPNT     PLTPAR,GPSETS,ELSETS $
22 GP3        GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $
23 CHKPNT     GPTT $
24 TA1        ECT,EPT,BGPD,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
25 SAVE      NOGENL,NOSIMP,GENEL $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

26	COND	ERROR1,NOSIMP \$
27	PURGE	OGPST/GENEL \$
28	CHKPNT	EST,GPECT,GEI,OGPST \$
29	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
30	PARAM	//C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 \$
31	EMG	EST,CSTM,MPT,DIT,GEUM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V, N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
32	SAVE	NOKGGX,NOMGG \$
33	CHKPNT	KELM,KDICT,MELM,MDICT \$
34	COND	JMPKGGX,NOKGGX \$
35	EMA	GPECT,KDICT,KELM/KGGX,GPST \$
36	CHKPNT	KGGX,GPST \$
37	LABEL	JMPKGGX \$
38	COND	ERROR1,NOMGG \$
39	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
40	CHKPNT	MGG \$
41	COND	LGPWG,GRDPNT \$
42	GPWG	BGPD,CTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS \$
43	OFF	OGPWG,,,,,// \$
44	LABEL	LGPWG \$
45	EQUIV	KGGX,KGG/NOGENL \$
46	CHKPNT	KGG \$
47	COND	LBL11,NOGENL \$
48	SMA3	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$
49	CHKPNT	KGG \$
50	LABEL	LBL11 \$
51	PARAM	//C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 \$
52	GP4	CASECC,GEUM4,EQEXIN,SIL,GPD,GPDT,BGPD,CTM/RG,,USET,ASET/ V,N,

MODAL COMPLEX EIGENVALUE ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

	LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
53	SAVE MPCF1,SINGLE,OMIT,REACT,NUSET,MPCF2,NSKIP,REPEAT,NOL,NOA \$
54	PARAM //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE \$
55	PURGE GM,GMD/MPCF1/GO,GOD/OMIT/KFS/SINGLE/QPC/NOSR/KLR,KRR,MLR,MRR, DM,MR/REACT \$
56	CHKPNT KRR,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,QPC,USET,GMD,GOD,ASET \$
57	COND LBL4,GENEL \$
58	GPSP GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
59	SAVE NOGPST \$
60	COND LBL4,NOGPST \$
61	OFF OGPST,,,,,// \$
62	LABEL LBL4 \$
63	EQUIV KGG,KNN/MPCF1/MGG,MNN/MPCF1 \$
64	CHKPNT KNN,MNN \$
65	COND LBL2,MPCF1 \$
66	MCE1 USET,RG/GM \$
67	CHKPNT GM \$
68	MCE2 USET,GM,KGG,MGG,,/KNN,MNN,, \$
69	CHKPNT KNN,MNN \$
70	LABEL LBL2 \$
71	EQUIV KNN,KFF/SINGLE/MNN,MFF/SINGLE \$
72	CHKPNT KFF,MFF \$
73	COND LBL3,SINGLE \$
74	SCE1 USET,KNN,MNN,,/KFF,KFS,,MFF,, \$
75	CHKPNT KFS,KFF,MFF \$
76	LABEL LBL3 \$
77	EQUIV KFF,KAA/OMIT \$
78	EQUIV MFF,MAA/OMIT \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10
N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

79	CHKPNT	KAA,MAA \$
80	COND	LBL5,UMIT \$
81	<u>SMP1</u>	USET,KFF,,,/GO,KAA,KOO,LOO,,,,, \$
82	CHKPNT	GO,KAA \$
83	<u>SMP2</u>	USET,GO,MFF/MAA \$
84	CHKPNT	MAA \$
85	LABEL	LBL5 \$
86	COND	LBL6,REACT \$
87	<u>RBMG1</u>	USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR \$
88	CHKPNT	KLL,KLR,KRR,MLL,MLR,MRR \$
89	<u>RBMG2</u>	KLL/LLL \$
90	CHKPNT	LLL \$
91	<u>RBMG3</u>	LLL,KLR,KRR/DM \$
92	CHKPNT	DM \$
93	<u>RBMG4</u>	DM,MLL,MLR,MRR/MR \$
94	CHKPNT	MR \$
95	LABEL	LBL6 \$
96	<u>DPD</u>	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,EED,EQDYN/V, N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NUDLT/V,N,NOPSDL/V,N,NOFRL/V, N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE \$
97	SAVE	LUSETD,NOUE,NOEED \$
98	COND	ERROR2,NOEED \$
99	EQUIV	GO,GOD/NOUE/GM,GMD/NOUE \$
100	CHKPNT	USETD,EED,EQDYN,TFPOOL,GOD,GMD,SILD,GPLD \$
101	PARAM	//C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 \$
102	<u>READ</u>	KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N, NEIGV \$
103	SAVE	NEIGV \$
104	CHKPNT	LAMA,PHIA,MI,OEIGS \$
105	PARAM	//C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 \$

MODAL COMPLEX EIGENVALUE ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

106	OFF	OEIGS,LAMA,,,,//V,N,CARDNO \$
107	SAVE	CARDNO \$
108	COND	ERROR4,NEIGV \$
109	PARAM	//C,N,ADD/V,N,NEVER/C,N,1/C,N,0 \$
110	PARAM	//C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 \$
111	JUMP	LBL13 \$
112	LABEL	LBL13 \$
113	PURGE	PHIH,CLAMA,UPHIH,CPHID,CPHIP,QPC,QQPC1,OCCHIP,UESC1,OEFC1,K2PP, M2PP,B2PP,K2DD,M2DD,B2DD/NEVER \$
114	CASE	CASECC,/CASEXX/C,N,CEIGN/V,N,REPEATE/V,N,NOLoop \$
115	SAVE	REPEATE,NOLoop \$
116	CHKPNT	CASEXX \$
117	MTRXIN	CASEXX,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N, NOK2PP/V,N,NOM2PP/V,N,NOB2PP \$
118	SAVE	NOK2PP,NOM2PP,NOB2PP \$
119	PURGE	K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP \$
120	EQUIV	M2PP,M2DD/NOSET/B2PP,B2DD/NOSET/K2PP,K2DD/NOSET \$
121	CHKPNT	K2PP,M2PP,B2PP,K2DD,M2DD,B2DD \$
122	GKAD	USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GDD,K2DD,M2DD,B2DD/C,N, CMPLV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V, N,NOM2PP/V,N,NOB2PP/ V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/ C,N,-1/C,N,-1/ C,N,-1/C,N,-1 \$
123	CHKPNT	K2DD,M2DD,B2DD,GDD,GMD \$
124	GKAM	USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX/MHH,BHH,KHH,PHIDH/ V,N,NOUE/C,Y,LMODES=999999/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N, NOM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE \$
125	SAVE	NONCUP,FMODE \$
126	CHKPNT	MHH,BHH,KHH,PHIDH \$
127	CEAD	KHH,BHH,MHH,EED,CASEXX/PHIH,CLAMA,OCEIGS/V,N,EIGVS \$
128	SAVE	EIGVS \$
129	CHKPNT	PHIH,CLAMA,OCEIGS \$
130	OFF	OCEIGS,CLAMA,,,,//V,N,CARDNO \$

Top of DMAP Loop

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10
N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

131	SAVE	CARDNO \$
132	COND	LBL17,EIGVS \$
133	VDR	CASEXX,EQDYN,USED,PHIH,CLAMA,,/OPHIH,/C,N,CEIGEN/C,N,MODAL/V, N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE \$
134	SAVE	NOH,NUP \$
135	COND	LBL16,NOH \$
136	OFF	OPHIH,,,,,//V,N,CARDNO \$
137	SAVE	CARDNO \$
138	LABEL	LBL16 \$
139	COND	LBL17,NUP \$
140	DDR1	PHIH,PHIDH/CPHID \$
141	CHKPNT	CPHID \$
142	EQUIV	CPHID,CPHIP/NOA \$
143	COND	LBLNOA,NOA \$
144	SDR1	USED,,CPHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1 /C,N,DYNAMICS \$
145	LABEL	LBLNOA \$
146	CHKPNT	CPHIP,QPC \$
147	SDR2	CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,CLAMA,QPC,CPHIP,EST,,/ UQPC1,UCPHIP,DESC1,DEFC1, /C,N,CEIGEN \$
148	OFF	UCPHIP,UQPC1,DEFC1,DESC1,,//V,N,CARDNO \$
149	SAVE	CARDNO \$
150	LABEL	LBL17 \$
151	COND	FINIS,REPEATE \$
152	REPT	LBL13,100 \$
153	JUMP	ERROR3 \$
154	JUMP	FINIS \$
155	LABEL	ERROR3 \$
156	PRTPARM	//C,N,-3/C,N,MDLCEAD \$
157	LABEL	ERROR2 \$

Bottom of DMAP Loop

MODAL COMPLEX EIGENVALUE ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

158 PRTPARM //C,N,-2/C,N,MDLCEAD \$
159 LABEL ERROR1 \$
160 PRTPARM //C,N,-1/C,N,MDLCEAD \$
161 LABEL ERROR4 \$
162 PRTPARM //C,N,-4/C,N,MDLCEAD \$
163 LABEL FINIS \$
164 END \$

RIGID FORMATS

3.11.2 Description of DMAP Operations for Modal Complex Eigenvalue Analysis

3. GP1 generates coordinate system transformation matrices, table of grid point locations, and tables for relating internal and external grid point numbers.
6. GP2 generates Element Connection Table with internal indices.
10. Go to DMAP No. 20 if no plot package is present.
11. PLTSET transforms user input into a form used to drive structure plotter.
13. PRTMSG prints error messages associated with structure plotter.
16. Go to DMAP No. 20 if no undeformed structure plot request.
17. PLØT generates all requested undeformed structure plots.
19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
22. GP3 generates Grid Point Temperature Table.
24. TAl generates element tables for use in matrix assembly and stress recovery.
26. Go to DMAP No. 159 and print error message if there are no structural elements.
31. EMG generates structural element matrix tables and dictionaries for later assembly.
34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.
35. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
38. Go to DMAP No. 159 if no mass matrix is to be assembled.
39. EMA assembles mass matrix $[M_{gg}]$.
41. Go to DMAP No. 44 if no weight and balance request.
42. GPWG generates weight and balance information.
43. ØFP formats weight and balance information and places it on the system output file for printing.
45. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
47. Go to DMAP No. 50 if no general elements.
48. SMA3 adds general elements to stiffness matrix $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
52. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.
57. Go to DMAP No. 62 if general elements present.
58. GPSP determines if possible grid point singularities remain.
60. Go to DMAP No. 62 if no Grid Point Singularity Table.
61. ØFP formats table of possible grid point singularities and places it on the system output file for printing.
63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

MODAL COMPLEX EIGENVALUE ANALYSIS

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & K_{nm} \\ K_{mn} & K_{mm} \end{bmatrix} \quad \text{and} \quad [M_{gg}] = \begin{bmatrix} \bar{M}_{nn} & M_{nm} \\ M_{mn} & M_{mm} \end{bmatrix}$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix}$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix}$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix}$$

performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

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86. Go to DMAP No. 95 if no free-body supports.

87. RBMG1 partitions out free-body supports.

89. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

91. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}$$

93. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

96. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

98. Go to DMAP No. 157 and print error message if no Eigenvalue Extraction Data.

99. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

102. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D_m \phi_{ro} \\ - - - \\ \phi_{ro} \end{bmatrix},$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

- 1) Unit value of selected coordinate
- 2) Unit value of largest component
- 3) Unit value of generalized mass.

106. ØFP formats the summary of eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

108. Go to DMAP No. 161 and print error message if no eigenvalues found.

111. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

MODAL COMPLEX EIGENVALUE ANALYSIS

112. Beginning of loop for additional sets of direct input matrices.
114. CASE extracts user requests from CASECC for current loop.
117. MTRXIN selects the direct input matrices for the current loop, $[K_{pp}^2]$, $[M_{pp}^2]$ and $[B_{pp}^2]$.
120. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied.
122. GKAD applies constraints to direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$ and $[B_{pp}^2]$, forming $[K_{dd}^2]$, $[M_{dd}^2]$ and $[B_{dd}^2]$.
124. GKAM assembles stiffness, mass and damping matrices in modal coordinates for use in Complex Eigenvalue Analysis.

$$[K_{hh}] = [k] + [\phi_{dh}^T][K_{dd}^2][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi_{dh}^T][M_{dd}^2][\phi_{dh}] ,$$

$$[B_{hh}] = [b] + [\phi_{dh}^T][B_{dd}^2][\phi_{dh}] ,$$

where

$$m_i = \text{modal masses}$$

$$b_i = m_i 2\pi f_i g(f_i)$$

$$k_i = m_i 4\pi^2 f_i^2$$

and direct input matrices may be complex.

127. CEAD extracts complex eigenvalues from the equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = 0$$

and normalizes eigenvectors according to one of the following user requests:

- (1) Unit magnitude of selected coordinate
- (2) Unit magnitude of largest component.

130. ØFP formats the summary of complex eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.
132. Go to DMAP No. 150 if no complex eigenvalues found.
133. VDR prepares eigenvectors for output, using only the extra points introduced for dynamic analysis and modal coordinates.
135. Go to DMAP No. 138 if no output request for the extra points introduced for dynamic analysis or modal coordinates.
136. ØFP formats eigenvectors for extra points introduced for dynamic analysis and modal coordinates and places them on the system output file for printing.
139. Go to DMAP No. 150 if no output request involving dependent degrees of freedom or forces and stresses.
140. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$[\phi_d] = [\phi_{dh}][\phi_h] .$$

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142. Equivalence $[\phi_d]$ to $[\phi_p]$ if no constraints applied.

143. Go to DMAP No. 145 if no constraints applied.

144. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_d\} \quad , \quad \begin{pmatrix} \phi_d \\ \phi_o \end{pmatrix} = \{\phi_f + \phi_e\} \quad ,$$

$$\begin{pmatrix} \phi_f + \phi_e \\ \phi_s \end{pmatrix} = \{\phi_n + \phi_e\} \quad , \quad \{\phi_m\} = [G_m^d]\{\phi_n + \phi_e\} \quad ,$$

$$\begin{pmatrix} \phi_n + \phi_e \\ \phi_m \end{pmatrix} = \{\phi_p\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$.

147. SDR2 calculates element forces and stresses ($\emptyset EFC1$, $\emptyset ESC1$) and prepares eigenvectors and single-point forces of constraint for output ($\emptyset CHIP$, $\emptyset PC1$).

148. $\emptyset FP$ formats tables prepared by SDR2 and places them on system output file for printing.

151. Go to DMAP No. 163 if no additional sets of direct input matrices need to be processed.

152. Go to DMAP No. 112 if additional sets of direct input matrices need to be processed.

153. Go to DMAP No. 155 and print error message if more than 100 loops.

154. Go to DMAP No. 163 and make normal exit.

156. MODAL COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE NO. 3 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

158. MODAL COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE NO. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.

160. MODAL COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE NO. 1 - MASS MATRIX REQUIRED FOR MODAL FORMULATION.

162. MODAL COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE NO. 4 - REAL EIGENVALUES REQUIRED FOR MODAL FORMULATION.

MODAL COMPLEX EIGENVALUE ANALYSIS

3.11.3 Automatic Output for Modal Complex Eigenvalue Analysis

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

The Complex Eigenvalue Summary Table and the Complex Eigenvalue Analysis Summary, as described under Direct Complex Eigenvalue Analysis, are automatically printed for each set of direct input matrices.

3.11.4 Case Control Deck and Parameters for Modal Complex Eigenvalue Analysis

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Complex Eigenvalue Analysis:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Complex Eigenvalue Analysis. Output for SØLUTION points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTION points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Complex Eigenvalue Analysis:

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1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.
3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.
5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

MODAL FREQUENCY AND RANDOM RESPONSE

3.12 MODAL FREQUENCY AND RANDOM RESPONSE

3.12.1 DMAP Sequence for Modal Frequency and Random Response

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 11

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

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1 BEGIN      NO.11 MODAL FREQUENCY RESPONSE ANALYSIS - SERIES N $
2 FILE       GOD=SAVE/ GMD=SAVE/ LAMA=APPEND/ PHIA=APPEND $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/ V,N,
              NUGPDT $
4 SAVE       LUSET $
5 CHKPNT     GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
6 GP2        GEOM2,EQEXIN/ECT $
7 CHKPNT     ECT $
8 PARAML     PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
9 PURGE      PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
10 COND      P1,NOPCDB $
11 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
              JUMPPLOT=-1 $
12 SAVE      NSIL,JUMPPLOT $
13 PRTMSG     PLTSETX// $
14 PARAM      //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
15 PARAM      //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
16 COND      P1,JUMPPLOT $
17 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
18 SAVE      PFILE $
19 PRTMSG     PLUTX1// $
20 LABEL      P1 $
21 CHKPNT     PLTPAR,GPSETS,ELSETS $
22 GP3        GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NUGRAV $
23 CHKPNT     GPTT $
24 TAIL       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N,
              NUSIMP/C,N,1/V,N,NUGENL/V,N,GENEL $
25 SAVE      NUGENL,NUSIMP,GENEL $

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RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 11

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

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26 COND      ERROR1,NOSIMP $
27 PURGE     OGPST/GENEL $
28 CHKPNT    EST,GPECT,GEI,OGPST $
29 PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
30 PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $
31 EMA       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAK/C,Y,CPRDD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIAL/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y,
              CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $
32 SAVE      NOKGGX,NOMGG $
33 CHKPNT    KELM,KDICT,MELM,MDICT $
34 COND      JMPKGGX,NOKGGX $
35 EMA       GPECT,KDICT,KELM/KGGX,GPST $
36 CHKPNT    KGGX,GPST $
37 LABEL     JMPKGGX $
38 COND      ERRUR1,NUMGG $
39 EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
40 CHKPNT    MGG $
41 COND      LGPWG,GRDPNT $
42 GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
43 OFP       OGPWG,,,,// $
44 LABEL     LGPWG $
45 EQUIV     KGGX,KGG/NOGENL $
46 CHKPNT    KGG $
47 COND      LBL11,NOGENL $
48 SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
49 CHKPNT    KGG $
50 LABEL     LBL11 $
51 PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
52 GP4       CASECC,GEDM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/ V,N,

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MODAL FREQUENCY AND RANDOM RESPONSE

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 11

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION

NO.		
		LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
53	SAVE	MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA \$
54	PARAM	//C,N,AND/V,N,NUSR/V,N,REACT/V,N,SINGLE \$
55	PURGE	GM,GMD/MPCF1/GU,GOD/OMIT/KFS,PSF/SINGLE/QPC/NOSR/KLR,KRR,MLR, MRR,DM,MR/REACT/MDD/MODACC \$
56	CHKPNT	KRR,KLR,DM,MLR,MRR,MR,GM,RG,GU,KFS,PSF,QPC,USET,GOD,GMD,ASET \$
57	COND	LBL4,GENEL \$
58	GPSP	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
59	SAVE	NOGPST \$
60	COND	LBL4,NOGPST \$
61	OFF	OGPST,,,,,// \$
62	LABEL	LBL4 \$
63	EQUIV	KGG,KNN/MPCF1/MGG,MNN/MPCF1 \$
64	CHKPNT	KNN,MNN \$
65	COND	LBL2,MPCF1 \$
66	MCE1	USET,RG/GM \$
67	CHKPNT	GM \$
68	MCE2	USET,GM,KGG,MGG,,/KNN,MNN,, \$
69	CHKPNT	KNN,MNN \$
70	LABEL	LBL2 \$
71	EQUIV	KNN,KFF/SINGLE/MNN,MFF/SINGLE \$
72	CHKPNT	KFF,MFF \$
73	COND	LBL3,SINGLE \$
74	SCE1	USET,KNN,MNN,,/KFF,KFS,,MFF,, \$
75	CHKPNT	KFS,KFF,MFF \$
76	LABEL	LBL3 \$
77	EQUIV	KFF,KAA/OMIT \$
78	EQUIV	MFF,MAA/OMIT \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 11

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

79	CHKPNT	KA,MAA \$
80	COND	LBL5,OMIT \$
81	<u>SMP1</u>	USET,KFF,,,/GO,KA,KUO,LOU,,,,, \$
82	CHKPNT	GO,KA \$
83	<u>SMP2</u>	USET,GO,MFF/MAA \$
84	CHKPNT	MAA \$
85	LABEL	LBL5 \$
86	EQUIV	KA,KLL/REACT \$
87	CHKPNT	KLL \$
88	COND	LBL6,REACT \$
89	<u>RBMG1</u>	USET,KA,MAA/KLL,KLR,KRR,MLL,MLR,MRR \$
90	CHKPNT	KLL,KLR,KRR,MLL,MLR,MRR \$
91	JUMP	LBL8 \$
92	LABEL	LBL6 \$
93	COND	LBL7,MODACC \$
94	LABEL	LBL8 \$
95	<u>RBMG2</u>	KLL/LLL \$
96	CHKPNT	LLL \$
97	COND	LBL7,REACT \$
98	<u>RBMG3</u>	LLL,KLR,KRR/DM \$
99	CHKPNT	DM \$
100	<u>RBMG4</u>	DM,MLL,MLR,MRR/MR \$
101	CHKPNT	MR \$
102	LABEL	LBL7 \$
103	<u>DPD</u>	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,, EED,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NUDLT/V,N,NOPSDL/ V,N,NOFRL/V,N,NOFLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE \$
104	SAVE	LUSETD,NOUE,NUDLT,NOFRL,NOEED,NUPSDL \$
105	COND	ERROR2,NOEED \$

MODAL FREQUENCY AND RANDOM RESPONSE

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 11

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

106	PURGE	UEVF/NOUE \$
107	EQUIV	GU,GOD/NOUE/GM,GMD/NOUE \$
108	CHKPNT	USETD,EQDYN,TFPOOL,DLT,FRL,EED,GOD,GMD,UEVF,SILD,PSDL,GPLD \$
109	PARAM	//C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 \$
110	READ	KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,DEIGS/C,N,MODES/V,N, NEIGV \$
111	SAVE	NEIGV \$
112	CHKPNT	LAMA,PHIA,MI,DEIGS \$
113	PARAM	//C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 \$
114	OFF	DEIGS,LAMA,,,,//V,N,CARDNO \$
115	SAVE	CARDNO \$
116	COND	ERROR4,NEIGV \$
117	PARAM	//C,N,ADD/V,N,NEVER/C,N,1/C,N,0 \$
118	PARAM	//C,N,MPY/V,N,REPEATF/C,N,1/C,N,-1 \$
119	JUMP	LBL13 \$
120	LABEL	LBL13 \$
121	PURGE	DUHVC1,DUHVC2,XYPLTFA,OPPC1,OQPC1,OUPVC1,DESC1,DEFC1,OPPC2, OQPC2,OUPVC2,DESC2,DEFC2,XYPLTF,PSDF,AUTO,XYPLTR,K2PP,M2PP, B2PP,K2DD,M2DD,B2DD,OPPCA,IQP1,IPHI1,IES1,IEF1,OPPC8,IQP2, IPHIP2,IES2,IEF2,ZQPC2,ZUPVC2,ZESC2,ZEFC2,ZQPC1,ZUPVC1,ZESC1, ZEFC1/NEVER \$
122	CASE	CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATF/V,N,NULOOP \$
123	SAVE	REPEATF,NULOOP \$
124	CHKPNT	CASEXX \$
125	MTRXIN	CASEXX,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N, NOK2PP/V,N,NOM2PP/V,N,NOB2PP \$
126	SAVE	NUK2PP,NOM2PP,NOB2PP \$
127	PURGE	K2DD/NUK2PP/M2DD/NOM2PP/B2DD/NOB2PP \$
128	PARAM	//C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP \$
129	EQUIV	M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA \$
130	CHKPNT	K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD \$

Top of DMAP Loop

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 11

NASTRAN SOURCE PROGRAM COMPI LATION
DMAP-DMAP INSTRUCTION
NO.

131	ⓀⓀⓀⓀ	USETD,GM,GO,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD, GOD,K2DD,M2DD, B2DD/C,N,FREQRESP/C,N,DISP/C,N,MODAL/C,N,O.O/ C,N,O.O/C,N,O.O/ V,N,NOK2PP/V,N,NOM2PP/V,N,NUB2PP/ V,N,MPCF1/V,N,SINGLE/V,N, OMIT/V,N,NOUE/C,N,-1/C,N,-1/ C,N,+1/V,Y,MODACC = -1 \$
132	CHKPNT	MDD,GMD,GOD,K2DD,M2DD,B2DD \$
133	ⓀⓀⓀⓀ	USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX/MHH,BHH,KHH,PHIDH/ V,N,NOUE/C,Y,LMODES=999999/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N, NOM2PP/V,N,NUB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE \$
134	SAVE	NONCUP,FMODE \$
135	CHKPNT	MHH,BHH,KHH,PHIDH \$
136	COND	ERROR5,NOFRL \$
137	CUND	ERROR6,NUDLT \$
138	ⓀⓀⓀⓀ	CASEXX,USETD,DLT,FRL,GMD,GOD,KHH,BHH,MHH,PHIDH,DLT/UHVF,PSF, PDF,PPF/C,N,DISP/C,N,MODAL/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N, OMIT/V,N,NONCUP/V,N,FRQSET \$
139	SAVE	FRQSET \$
140	EQUIV	PPF,PDF/NOSET \$
141	CHKPNT	PSF,PPF,UHVF,PDF \$
142	ⓀⓀⓀⓀ	CASEXX,EQDYN,USETD,UHVF,PPF,XYCDB,/OUHVC1,/C,N,FREQRESP/C,N, MODAL/V,N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE \$
143	SAVE	NOH,NOP,NOSORT2 \$
144	COND	LBL16,NOH \$
145	COND	LBL16A,NOSORT2 \$
146	CHKPNT	OUHVC1 \$
147	ⓀⓀⓀⓀ	OUHVC1,,,,, /OUHVC2,,,,, \$
148	DFP	OUHVC2,,,,, //V,N,CARDNO \$
149	SAVE	CARDNO \$
150	CHKPNT	OUHVC2 \$
151	ⓀⓀⓀⓀ	XYCDB,OUHVC2,,,,, /XYPLTFA/C,N,FREQ/C,N,HSET/V,N,PFILE/V,N, CARDNO \$
152	SAVE	PFILE,CARDNO \$
153	ⓀⓀⓀⓀ	XYPLTFA // \$
154	JUMP	LBL16 \$

MODAL FREQUENCY AND RANDOM RESPONSE

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RIGID FORMAT 11

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DMAP-DMAP INSTRUCTION
NO.

155	LABEL	LBL16A \$
156	OFF	UUHVC1,,,,,//V,N,CARDNU \$
157	SAVE	CARDNU \$
158	LABEL	LBL16 \$
159	COND	LBL14,NOP \$
160	PARAM	//C,N,NOT/V,N,NUMOD/V,Y,MODACC \$
161	COND	LBDORM,MODACC \$
162	DDR1	UHVf,PHIDH/UDV1F \$
163	CHKPNT	UDV1F \$
164	DDR2	USETD,UDV1F,PDF,K2DD,B2DD,MOD,PPF,LLL,DM/UDV2F,UEVF,PAF/ C,N, FREQRESP/V,N,NOUE/V,N,REACT/V,N,FRQSET \$
165	CHKPNT	UDV2F,UEVF,PAF \$
166	EQUIV	UDV2F,UDV1F/NUMOD \$
167	CHKPNT	UDV1F \$
168	EQUIV	UDV1F,UPVC/NOA \$
169	COND	LBLNOA,NOA \$
170	SDR1	USETD,,UDV1F,,,GOD,GMD,PSF,KFS,,/UPVC,,QPC/C,N,1/C,N,DYNAMICS \$
171	LABEL	LBLNOA \$
172	CHKPNT	UPVC,QPC \$
173	SDR2	CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,PPF,QPC,UPVC,EST,XYCDB,PPF/ OPPC1,UQPC1,OUPVC1,OESC1,OEFCL,/C,N,FREQ/V,N,NOSORT2 \$
174	SAVE	NUSORT2 \$
175	COND	LBL18,NOSORT2 \$
176	SDR3	UPPC1,OQPC1,OUPVC1,OESC1,OEFCL,/OPPC2,UQPC2,OUPVC2,OESC2, OEFCL2, \$
177	JUMP	P2A \$
178	LABEL	LBDORM \$
179	SDR1	USETD,,PHIDH,,,GOD,GMD,,KFS,,/PHIPH,,QPH/C,N,1/C,N,DYNAMICS \$
180	SDR2	CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,LAMA,QPH,PHIPH,EST,XYCDB,/ , IQP1,IPHIP1,IES1,IEF1,/C,N,MMREIG/V,N,NOSORT2 \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 11

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

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181  SAVE      NUSORT2 $
182  (SDR2)    CASEXX,,,,EQDYN,SILD,,,,PPF,,,,XYCDB,PPF/OPPCA,,,,,/C,N,FREQ $
183  EQUIV     OPPCA,OPPC1/MODACC $
184  COND      LBLSORT,NOSORT2 $
185  (SDR3)    IQP1,IPHIP1,IES1,IEF1,OPPCA,/IQP2,IPHIP2,IES2,IEF2,OPPCB, $
186  EQUIV     OPPCB,OPPC2/MODACC $
187  (DDRMM)   CASEXX,UHVF,PPF,IPHIP2,IQP2,IES2,IEF2,,EST,MPT,DIT/    ZUPVC2,
              ZQPC2,ZESC2,ZEFC2, $
188  EQUIV     ZUPVC2,OUPVC2/MODACC/ZQPC2,OQPC2/MODACC/ZESC2,OESC2/MODACC/
              ZEFC2,OEFC2/MODACC $
189  JUMP      P2A $
190  LABEL     LBLSORT $
191  (DDRMM)   CASEXX,UHVF,PPF,IPHIP1,IQP1,IES1,IEF1,,EST,MPT,DIT/    ZUPVC1,
              ZQPC1,ZESC1,ZEFC1, $
192  EQUIV     ZUPVC1,OUPVC1/MODACC/ZQPC1,OQPC1/MODACC/ZESC1,OESC1/MODACC/
              ZEFC1,OEFC1/MODACC $
193  JUMP      LBL18 $
194  LABEL     P2A $
195  CHPNT     OUPVC2,OPPC2,OQPC2,OESC2,OEFC2 $
196  OFP       OPPC2,OQPC2,OUPVC2,OEFC2,OESC2,/,V,N,CARDNO $
197  SAVE      CARDNO $
198  (XYTRAN)  XYCDB,OPPC2,OQPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
              V,N,PFILE/V,N,CARDNO $
199  SAVE      PFILE,CARDNO $
200  (XYPLOT)  XYPLTF// $
201  COND      LBL14,NOPSDL $
202  (RANDOM)   XYCDB,DIT,PSDL,OUPVC2,OPPC2,OQPC2,OESC2,OEFC2,CASEXX/PSDF,AUTO/
              V,N,NORD $
203  SAVE      NORD $
204  CHPNT     PSDF,AUTO $
205  COND      LBL14,NORD $

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MODAL FREQUENCY AND RANDOM RESPONSE

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RIGID FORMAT 11

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

206	XYTRAN	XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/	V,N,
		CARDNU \$	
207	SAVE	PFILE,CARDNU \$	
208	XYPLOT	XYPLTR// \$	
209	JUMP	LBL14 \$	
210	LABEL	LBL18 \$	
211	OPF	OUPVC1,UPPC1,OQPC1,OEFC1,DESC1,/,V,N,CARDNU \$	
212	SAVE	CARDNU \$	
213	LABEL	LBL14 \$	
214	COND	FINIS,REPEATF \$	
215	KEPT	LBL13,100 \$	
			Bottom of DMAP Loop
216	JUMP	ERROR3 \$	
217	JUMP	FINIS \$	
218	LABEL	ERROR3 \$	
219	PRTPARM	//C,N,-3/C,N,MDLFRRD \$	
220	LABEL	ERROR2 \$	
221	PRTPARM	//C,N,-2/C,N,MDLFRRD \$	
222	LABEL	ERROR1 \$	
223	PRTPARM	//C,N,-1/C,N,MDLFRRD \$	
224	LABEL	ERROR4 \$	
225	PRTPARM	//C,N,-4/C,N,MDLFRRD \$	
226	LABEL	ERROR5 \$	
227	PRTPARM	//C,N,-5/C,N,MDLFRRD \$	
228	LABEL	ERROR6 \$	
229	PRTPARM	//C,N,-6/C,N,MDLFRRD \$	
230	LABEL	FINIS \$	
231	END	\$	

RIGID FORMATS

3.12.2 Description of DMAP Operations for Modal Frequency and Random Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
6. GP2 generates Element Connection Table with internal indices.
10. Go to DMAP No. 20 if no plot package is present.
11. PLTSET transforms user input into a form used to drive structure plotter.
13. PRTMSG prints error messages associated with structure plotter.
16. Go to DMAP No. 20 if no undeformed structure plot request.
17. PLØT generates all requested undeformed structure plots.
19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
22. GP3 generates Grid Point Temperature Table.
24. TAI generates element tables for use in matrix assembly and stress recovery.
26. Go to DMAP No. 222 and print error messages if there are no structural elements.
31. EMG generates structural element matrix tables and dictionaries for later assembly.
34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.
35. EMA assembles stiffness matrix $[K_{gg}^X]$ and Grid Point Singularity Table.
38. Go to DMAP No. 222 if no mass matrix is to be assembled.
39. EMA assembles stiffness matrix $[M_{gg}]$.
41. Go to DMAP No. 44 if no weight and balance request.
42. GPWG generates weight and balance information.
43. ØFP formats weight and balance information and places it on the system output file for printing.
45. Equivalence $[K_{gg}^X]$ to $[K_{gg}]$ if no general elements.
47. Go to DMAP No. 50 if no general elements.
48. SMA3 adds general elements to stiffness matrix $[K_{gg}^X]$ to obtain stiffness matrix $[K_{gg}]$.
52. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.
57. Go to DMAP No. 62 if general elements present.
58. GPSP determines if possible grid point singularities remain.
60. Go to DMAP No. 62 if no grid point singularities remain.
61. ØFP formats table of possible grid point singularities and places it on the system output file for printing.
63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

MODAL FREQUENCY AND RANDOM RESPONSE

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m^T R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & K_{nm} \\ K_{mn} & K_{mm} \end{bmatrix} \quad \text{and} \quad [M_{gg}] = \begin{bmatrix} \bar{M}_{nn} & M_{nm} \\ M_{mn} & M_{mm} \end{bmatrix}$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix}$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix}$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix.

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

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86. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

88. Go to DMAP No. 92 if no free-body supports.

89. RBMG1 partitions out free-body supports

$$[K_{aa}] = \begin{bmatrix} K_{\ell\ell} & K_{\ell r} \\ K_{r\ell} & K_{rr} \end{bmatrix} \quad \text{and} \quad [M_{aa}] = \begin{bmatrix} M_{\ell\ell} & M_{\ell r} \\ M_{r\ell} & M_{rr} \end{bmatrix}$$

91. Go to DMAP No. 94.

93. Go to DMAP No. 102 if no request for mode acceleration data recovery.

95. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

97. Go to DMAP No. 102 if no free-body supports.

98. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}$$

100. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

103. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamic Loads Table, Power Spectral Density List, Frequency Response List and Eigenvalue Extraction Data.

105. Go to DMAP No. 220 and print error message if no Eigenvalue Extraction Data.

107. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

110. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D_m \phi_{ro} \\ \phi_{ro} \end{bmatrix},$$

MODAL FREQUENCY AND RANDOM RESPONSE

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

- 1) Unit value of selected coordinate
- 2) Unit value of largest component
- 3) Unit value of generalized mass.

114. ØFP formats the summary of eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.
116. Go to DMAP No. 224 and print error message if no eigenvalues found.
119. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.
120. Beginning of loop for additional sets of direct input matrices.
122. CASE extracts user requests from CASECC for current loop.
125. MTRXIN selects the direct input matrices for the current loop, $[K_{pp}^2]$, $[M_{pp}^2]$ and $[B_{pp}^2]$.
129. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied and $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points introduced for Dynamic analysis.
131. GKAD applies constraints to direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$ and $[B_{pp}^2]$, forming $[K_{dd}^2]$, $[M_{dd}^2]$ and $[B_{dd}^2]$.
133. GKAM assembles stiffness mass and damping matrices in modal coordinates for use in Frequency Response.

$$[K_{hh}] = [k] + [\phi_{dh}^T][K_{dd}^2][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi_{dh}^T][M_{dd}^2][\phi_{dh}] ,$$

$$[B_{hh}] = [b] + [\phi_{dh}^T][B_{dd}^2][\phi_{dh}] ,$$

where

$$m_i = \text{modal masses}$$

$$b_i = m_i 2\pi f_i g(f_i)$$

$$k_i = m_i 4\pi^2 f_i^2$$

and direct input matrices may be complex.

136. Go to DMAP No. 226 and print error message if no Frequency Response List.
137. Go to DMAP No. 228 and print error message if no Dynamic Loads Table.
138. FRRD forms the dynamic load vectors $\{P_h\}$ and solves for the displacements using the following equation

$$[-M_{hh}\omega^2 + iB_{hh}\omega + K_{hh}']\{u_h\} = \{P_h\}.$$

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140. Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.
142. VDR prepares displacements, sorted by frequency, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).
144. Go to DMAP No. 158 if no output request for solution points.
145. Go to DMAP No. 155 if no output request for solution points sorted by extra point or mode number.
147. SDR3 sorts the solution point displacements by extra point or mode number.
148. ØFP formats the requested solution point displacements sorted by extra point or mode number and places them on the system output file for printing.
151. XYTRAN prepares the input for X-Y plotting of the solution point displacements vs. frequency.
153. XYPLØT prepares requested X-Y plots of the solution point displacements vs. frequency.
154. Go to DMAP No. 158.
156. ØFP formats the requested solution point displacements sorted by frequency and places them on the system output file for printing.
159. Go to DMAP No. 213 if no output request involving dependent degrees of freedom or forces and stresses.
161. Go to DMAP No. 178 if mode acceleration technique not requested.
162. DDR1 transforms the solution vector of displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\}$$

164. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.
168. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.
169. Go to DMAP No. 171 if no constraints applied.
170. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \quad , \quad \begin{pmatrix} u_d \\ - \\ u_o \end{pmatrix} = \{u_f + u_e\} \quad ,$$

$$\begin{pmatrix} u_f + u_e \\ - \\ u_s \end{pmatrix} = \{u_n + u_e\} \quad , \quad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\begin{pmatrix} u_n + u_e \\ - \\ u_m \end{pmatrix} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

MODAL FREQUENCY AND RANDOM RESPONSE

173. SDR2 calculates element forces and stresses ($\emptyset\text{EFC1}$, $\emptyset\text{ESC1}$) and prepares load vectors, displacement vectors and single-point forces of constraint for output ($\emptyset\text{PPC1}$, $\emptyset\text{UPVC1}$, $\emptyset\text{QPC1}$) - all sorted by frequency.
175. Go to DMAP No. 210 if no output requests sorted by point number or element number.
176. SDR3 prepares requested output sorted by point number or element number.
177. Go to DMAP No. 194 because no mode accelerations requested.
179. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_n\} \quad , \quad \begin{Bmatrix} \phi_n \\ -\phi_o \end{Bmatrix} = \{\phi_f + u_e\}$$

$$\begin{Bmatrix} \phi_f + u_e \\ -\phi_s \end{Bmatrix} = \{\phi_n + u_e\} \quad \{\phi_m\} = [G_m^d]\{\phi_n + u_e\}$$

$$\begin{Bmatrix} \phi_n + u_e \\ -\phi_m \end{Bmatrix} = \{\phi_g + u_e\} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}]^T\{\phi_f\} \quad .$$

180. SDR2 calculates element forces and stresses (IEF1 , IES1) and prepares eigenvectors and single-point forces of constraint for output (IPHIP1 , IQP1) - all sorted by frequency.
182. SDR2 prepares load vectors for output ($\emptyset\text{PPCA}$) - sorted by frequency.
183. Equivalence $\emptyset\text{PPCA}$ to $\emptyset\text{PPC1}$ if mode acceleration requested.
184. Go to DMAP No. 190 if no output requested by point number or element number sort.
185. SDR3 prepares requested output sorted by point number or element number.
186. Equivalence $\emptyset\text{PPCB}$ to $\emptyset\text{PPC2}$ if mode acceleration requested.
187. DDRMM prepares a subset of the element forces and stresses (ZEF2 , ZESC2), and displacement vectors and single-point forces of constraint (ZUPVC2 , ZQPC2) solutions for output by point number or element number sort.
188. Equivalence ZUPVC2 to $\emptyset\text{UPVC2}$, ZQPC2 to $\emptyset\text{QPC2}$, ZESC2 to $\emptyset\text{ESC2}$, and ZEF2 to $\emptyset\text{EFC2}$ if mode acceleration requested.
189. Go to DMAP No. 194 because requested output is sorted by point number or element number.
191. DDRMM prepares a subset of the element forces and stresses (ZEF1 , ZESC1) and displacement vectors and single-point forces of constraint (ZUPVC1 , ZQPC1) solutions for output.
192. Equivalence ZUPVC1 to $\emptyset\text{UPVC1}$, ZQPC1 to $\emptyset\text{QPC1}$, ZESC1 to $\emptyset\text{ESC1}$, and ZEF1 to $\emptyset\text{EFC1}$ if mode accelerations requested.
193. Go to DMAP No. 210 because requested output is not sorted by point number or element number.

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- 196. ØFP formats the requested output sorted by point number or element number and places it on the system output file for printing.
- 198. XYTRAN prepares the input for requested X-Y plots.
- 200. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.
- 201. Go to DMAP No. 213 if no Power Spectral Density List.
- 202. RANDØM calculates power spectral density functions and autocorrelation functions using the previously calculated frequency response.
- 205. Go to DMAP No. 213 if no RANDØM calculations requested.
- 206. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.
- 208. XYPLØT prepares requested X-Y plots of autocorrelation functions and power spectral density functions.
- 209. Go to DMAP No. 213 because there are no frequency response output requests sorted by frequency.
- 211. ØFP formats the frequency response output requests sorted by frequency and places them on the system output file for printing.
- 214. Go to DMAP No. 230 if no additional sets of direct input matrices need to be processed.
- 215. Go to DMAP No. 120 if additional sets of direct input matrices need to be processed.
- 216. Go to DMAP No. 218 and print error message if more than 100 loops.
- 217. Go to DMAP No. 230 and make normal exit.
- 219. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.
- 221. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.
- 223. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATION.
- 225. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATION.
- 227. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 5 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIONS.
- 229. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 6 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIONS.

MODAL FREQUENCY AND RANDOM RESPONSE

3.12.3 Automatic Output for Modal Frequency and Random Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.12.4 Case Control Deck and Parameters for Modal Frequency and Random Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Frequency and Random Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMPI table if structural damping is desired.

Output that may be requested is the same as that described under Direct Frequency and Random Response. Output for SØLUTION points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTION points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Frequency and Random Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

RIGID FORMATS

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.
3. C0UPMASS - CPBAR, CPR0D, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
4. LFREQ and HFREQ - required unless LM0DES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.
5. LM0DES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.
6. M0DACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

MODAL TRANSIENT RESPONSE

3.13 MODAL TRANSIENT RESPONSE

3.13.1 DMAP Sequence for Modal Transient Response

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 12

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NU.

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1 BEGIN      NO.12 MODAL TRANSIENT RESPONSE ANALYSIS - SERIES N $
2 FILE      LAMA=APPEND/PHIA=APPEND/UHVT=APPEND $
3 GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/ V,N,
            NOGPDT $
4 SAVE      LUSET $
5 CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
6 GP2       GEOM2,EQEXIN/ECT $
7 CHKPNT    ECT $
8 PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
9 PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
10 COND     P1,NOPCDB $
11 PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
            JUMPLOT=-1 $
12 SAVE     NSIL,JUMPLOT $
13 PRTMSG    PLTSETX// $
14 PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
15 PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
16 COND     P1,JUMPLOT $
17 PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,/PLOTX1/ V,N,
            NSIL/V,N,LUSET/V,N,JUMPLOT/V,N,PLTFLG/V,N,PFILE $
18 SAVE     JUMPLOT,PLTFLG,PFILE $
19 PRTMSG    PLOTX1// $
20 LABEL    P1 $
21 CHKPNT    PLTPAR,GPSETS,ELSETS $
22 GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $
23 CHKPNT    SLT,GPTT $
24 TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N,
            NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
25 SAVE     NOGENL,NOSIMP,GENEL $

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RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

26	COND	ERROR1,NOSIMP \$
27	PURGE	UGPST/GENEL \$
28	CHKPNT	EST,GPECT,GEI,UGPST \$
29	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
30	PARAM	//C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 \$
31	EMG	EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V, N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPRDD/C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
32	SAVE	NOKGGX,NUMGG \$
33	CHKPNT	KELM,KDICT,MELM,MDICT \$
34	COND	JMPKGGX,NOKGGX \$
35	EMA	GPECT,KDICT,KELM/KGGX,GPST \$
36	CHKPNT	KGGX,GPST \$
37	LABEL	JMPKGGX \$
38	COND	ERROR1,NOMGG \$
39	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
40	CHKPNT	MGG \$
41	COND	LGPWG,GRDPNT \$
42	GPWG	BGPD, CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS \$
43	OFF	OGPWG,,,,// \$
44	LABEL	LGPWG \$
45	EQUIV	KGGX,KGG/NOGENL \$
46	CHKPNT	KGG \$
47	COND	LBL11,NOGENL \$
48	SMA3	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$
49	CHKPNT	KGG \$
50	LABEL	LBL11 \$
51	PARAM	//C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 \$
52	GP4	CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPD,CSTM/RG,,USET,ASET/ V,N,

MODAL TRANSIENT RESPONSE

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 12

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

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    LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,
    NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

53  SAVE      MPCF1,SINGLE,OMIT,REACT,NUSET,MPCF2,NSKIP,REPEAT,NOL,NOA $
54  PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $
55  PURGE     GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST/SINGLE/QP/NOSR/KLR,KRR,MLR,MR,
    MRR,DM/REACT $
56  CHKPNT    KRR,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,PST,QP,USET,GOD,GMD,ASET $
57  COND      LBL4,GENEL $
58  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
59  SAVE      NOGPST $
60  COND      LBL4,NOGPST $
61  OFP       OGPST,,,,,// $
62  LABEL     LBL4 $
63  EQUIV     KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
64  CHKPNT    KNN,MNN $
65  COND      LBL2,MPCF1 $
66  MCE1      USET,RG/GM $
67  CHKPNT    GM $
68  MCE2      USET,GM,KGG,MGG,,/KNN,MNN,, $
69  CHKPNT    KNN,MNN $
70  LABEL     LBL2 $
71  EQUIV     KNN,KFF/SINGLE/MNN,MFF/SINGLE $
72  CHKPNT    KFF,MFF $
73  COND      LBL3,SINGLE $
74  SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $
75  CHKPNT    KFS,KFF,MFF $
76  LABEL     LBL3 $
77  EQUIV     KFF,KAA/OMIT $
78  EQUIV     MFF,MAA/OMIT $

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RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 12

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

79	CHKPNT	KA A,MAA \$
80	COND	LBL5,OMIT \$
81	<u>SMP1</u>	USET,KFF,,,/GO,KA A,KUD,LOO,,,, \$
82	CHKPNT	GU,KA A \$
83	<u>SMP2</u>	USET,GO,MFF/MAA \$
84	CHKPNT	MAA \$
85	LABEL	LBL5 \$
86	EQUIV	KA A,KLL/REACT \$
87	CHKPNT	KLL \$
88	COND	LBL6,REACT \$
89	<u>RBMG1</u>	USET,KA A,MAA/KLL,KLR,KRR,MLL,MLR,MRR \$
90	CHKPNT	KLL,KLR,KRR,MLL,MLR,MRR \$
91	JUMP	LBL8 \$
92	LABEL	LBL6 \$
93	COND	LBL7,MODACC \$
94	LABEL	LBL8 \$
95	<u>RBMG2</u>	KLL/LLL \$
96	CHKPNT	LLL \$
97	COND	LBL7,REACT \$
98	<u>RBMG3</u>	LLL,KLR,KRR/DM \$
99	CHKPNT	DM \$
100	<u>RBMG4</u>	DM,MLL,MLR,MRR/MR \$
101	CHKPNT	MR \$
102	LABEL	LBL7 \$
103	<u>DPD</u>	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL, EED ,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/ V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE \$
104	SAVE	LUSETD,NODLT,NONLFT,NOTRL,NOUE,NOEED \$
105	COND	ERROR2,NOEED \$

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

106	PURGE	UEVT/NOUE/PNLH/NONLFT \$
107	EQUIV	GO,GOD/NOUE/GM,GMD/NOUE \$
108	CHKPNT	USETD,EQDYN,TFPOOL,DLT,TRL,EED,GOD,GMD,UEVT,NLFT,PNLH,SILD, GPLD \$
109	PARAM	//C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 \$
110	READ	KAA,MAA,MR,DM,EED,uset,CASECC/LAMA,PHIA,MI,DEIGS/C,N,MODES/V,N, NEIGV \$
111	SAVE	NEIGV \$
112	CHKPNT	LAMA,PHIA,MI,DEIGS \$
113	PARAM	//C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 \$
114	OFF	DEIGS,LAMA,,,,//V,N,CARDNO \$
115	SAVE	CARDNO \$
116	COND	ERROR4,NEIGV \$
117	MTRXIN	CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N, NOK2PP/V,N,NOM2PP/V,N,NOB2PP \$
118	SAVE	NOK2PP,NOM2PP,NOB2PP \$
119	PURGE	K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP \$
120	PARAM	//C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP \$
121	EQUIV	M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MOD/MDEMA \$
122	CHKPNT	K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MOD \$
123	GKAD	USETD,GM,GD,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD, GOD,K2DD,M2DD, B2DD/C,N,TRANRESP/C,N,DISP/C,N,MODAL/C,N,0.0/ C,N,0.0/C,N,0.0/ V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/ V,N,MPCF1/V,N,SINGLE/V,N, OMIT/V,N,NOUE/C,N,-1/C,N,-1/ C,N,+1/V,Y,MODACC = -1 \$
124	CHKPNT	MDD,GMD,GDD,K2DD,M2DD,B2DD \$
125	GKAM	USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIOH/ V,N,NOUE/C,Y,LMODES=999999/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N, NOM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE \$
126	SAVE	NONCUP,FMODE \$
127	CHKPNT	MHH,BHH,KHH,PHIOH \$
128	COND	ERROR5,NUTRL \$
129	PARAM	//C,N,ADD/V,N,NEVER/C,N,1/C,N,0 \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 12

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

130	PARAM	//C,N,MPY/V,N,REPEAT/C,N,1/C,N,-1 \$
131	JUMP	LBL13 \$
132	LABEL	LBL13 \$
133	PURGE	PNLH,OUHV1,OPNL1,OUHV2,OPNL2,XYPLTTA,OPP1,UQP1,OUVP1,UES1,DEF1, OPP2,OQP2,OUVP2,UES2,DEF2,PLOTX2,XYPLTT,OPPA,IQP1,IPHIP1,IES1, IEF1,OPPB,IQP2,IPHIP2,IES2,IEF2,ZQP2,ZUPV2,ZES2,ZEF2/NEVER \$
134	CASE	CASECC,/CASEXX/C,N,TRAN/V,N,REPEAT/V,N,NOLoop \$
135	SAVE	REPEAT,NOLoop \$
136	CHKPNT	CASEXX \$
137	PARAM	//C,N,MPY/V,N,NCOL/C,N,0/C,N,1 \$
138	TRLG	CASEXX,USED,DLT,SLT,BGPD,SL,CSTM,TRL,DIT,GMD,GOD,PHIDH, EST, MGG/PPT,PST,PDT,PD,PH,TOL/V,N,NOSET/V,N,PDEPDO/V,N,NCOL \$
139	SAVE	PDEPDO,NOSET \$
140	CHKPNT	PPT,PST,PDT,PD,PH,TOL \$
141	EQUIV	PD,PDT/PDEPDO/PPT,PDT/NOSET \$
142	CHKPNT	PDT \$
143	TRD	CASEXX,TRL,NLFT,DIT,KHH,BHH,MHH,PH/UHVT,PNLH/C,N,MODAL/V,N, NOUE/V,N,NONCUP/V,N,NCOL \$
144	SAVE	NCOL \$
145	CHKPNT	UHVT,PNLH \$
146	VDR	CASEXX,EQDYN,USED,UHVT,TOL,XYCDB,PNLH/OUHV1,OPNL1/C,N, TRANRESP/C,N,MODAL/C,N,0/V,N,NOH/V,N,NOP/V,N,FMODE \$
147	SAVE	NOH,NOP \$
148	CHKPNT	OUHV1,OPNL1 \$
149	CUND	LBL16,NOH \$
150	SDR3	OUHV1,OPNL1,,,/OUHV2,OPNL2,,, \$
151	OPF	OUHV2,OPNL2,,,/V,N,CARDNO \$
152	SAVE	CARDNO \$
153	CHKPNT	OPNL2,OUHV2 \$
154	XYTRAN	XYCDB,OUHV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,HSET/V,N,PFILE/V,N, CARDNO \$

Top of DMAP Loop

MODAL TRANSIENT RESPONSE

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 12

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NU.

```

155 SAVE      PFILE,CARDNO $
156 XYPLOT    XYPLTTA// $
157 LABEL     LBL16 $
158 PARAM     //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $
159 COND      LBL15,PJUMP $
160 PARAM     //C,N,NOT/V,N,NOMOD/V,Y,MODACC $
161 PARAM     //C,N,AND/V,N,MPJUMP/V,Y,MODACC/V,N,JUMPPLOT $
162 CUND      LBDDRM,MPJUMP $
163 DDR1      UHVT,PHIDH/UDVIT $
164 CHKPNT     UDVIT $
165 COND      LBLMOD,MODACC $
166 DDR2      USETD,UDVIT,PDT,K2DD,B2DD,MOD,,LLL,DM/UDV2T,UEVT,PAF/ C,N,
TRANRESP/V,N,NOUE/V,N,REACT/C,N,O $
167 CHKPNT     UDV2T,UEVT,PAF $
168 EQUIV      UDV2T,UDVIT/NUMOD $
169 CHKPNT     UDVIT $
170 LABEL     LBLMOD $
171 EQUIV      UDVIT,UPV/NOA $
172 COND      LBL14,NOA $
173 SDR1      USETD,,UDVIT,,,GDD,GMD,PST,KFS,,/UPV,,QP/C,N,1/C,N,DYNAMICS $
174 LABEL     LBL14 $
175 CHKPNT     UPV,QP $
176 SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,TOL,QP,UPV,EST,XYCDB,
PPT/OPP1,OQP1,OUPV1,OES1,DEF1,PUGV/C,N,TRANRESP $
177 SDR3      OPP1,OQP1,OUPV1,OES1,DEF1,/OPP2,OQP2,OUPV2,OES2,DEF2, $
178 JUMP      P2A $
179 LABEL     LBDDRM $
180 SDR1      USETD,,PHIDH,,,GDD,GMD,,KFS,,/PHIPH,,QPH/C,N,1/C,N,REIG $
181 SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,LAMA,QPH,PHIPH,EST,XYCDB,/
,IQP1,IPHIP1,IES1,IEF1,/C,N,MMREIG $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 12

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

182	(SDR2)	CASEXX, , , , EQDYN, SILD, , , , TOL, , , , XYCDB, PPT/UPPA, , , , /C, N, TRANRESP \$
183	(SDR3)	OPPA, IQP1, IPHIP1, IES1, IEF1, /OPP8, IQP2, IPHIP2, IES2, IEF2, \$
184	EQUIV	OPP8, OPP2/MODACC \$
185	(DDRMM)	CASEXX, UHVT, TOL, IPHIP2, IQP2, IES2, IEF2, , EST, MPT, DIT/ ZUPV2, ZQP2, ZES2, ZEF2, \$
186	EQUIV	ZUPV2, OUPV2/MODACC/ZQP2, OQP2/MODACC/ZEF2, OEF2/MODACC/ZES2, OES2/ MODACC \$
187	LABEL	P2A \$
188	CHKPNT	OPP2, OQP2, OUPV2, OES2, OEF2 \$
189	UFP	OUPV2, OPP2, OQP2, OEF2, OES2, //V, N, CARDNO \$
190	SAVE	CARDNO \$
191	COND	P2, JUMPLOT \$
192	(PLOT)	PLTPAR, GPSETS, ELSETS, CASEXX, BGPDT, EQEXIN, SIL, , , PUGV, , /PLOTX2/ V, N, NSIL/V, N, LUSSET/V, N, JUMPLOT/V, N, PLTFLG/V, N, PFILE \$
193	SAVE	PFILE \$
194	PRMSG	PLOTX2// \$
195	LABEL	P2 \$
196	(XYTRAN)	XYCDB, OPP2, OQP2, OUPV2, OES2, OEF2/XYPLTT/C, N, TRAN/C, N, PSET/V, N, PFILE/V, N, CARDNO \$
197	SAVE	PFILE, CARDNO \$
198	(XYPLOT)	XYPLTT// \$
199	LABEL	LBL15 \$
200	COND	FINIS, REPEAT \$
201	REPT	LBL13, 100 \$
202	JUMP	ERROR3 \$
203	JUMP	FINIS \$
204	LABEL	ERROR3 \$
205	PRTPARM	//C, N, -3/C, N, MDLTRD \$
206	LABEL	ERROR2 \$
207	PRTPARM	//C, N, -2/C, N, MDLTRD \$

Bottom of DMAP Loop

MODAL TRANSIENT RESPONSE

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 12

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

208 LABEL ERROR1 \$
209 PRTPARM //C,N,-1/C,N,MDLTRD \$
210 LABEL ERROR4 \$
211 PRTPARM //C,N,-4/C,N,MDLTRD \$
212 LABEL ERROR5 \$
213 PRTPARM //C,N,-5/C,N,MDLTRD \$
214 LABEL FINIS \$
215 END \$

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3.13.2 Description of DMAP Operations for Modal Transient Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
6. GP2 generates Element Connection Table with internal indices.
10. Go to DMAP No. 20 if no plot package is present.
11. PLTSET transforms user input into a form used to drive structure plotter.
13. PRTMSG prints error messages associated with structure plotter.
16. Go to DMAP No. 20 if no undeformed structure plot request.
17. PLØT generates all requested undeformed structure plots.
19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
22. GP3 generates Grid Point Temperature Table.
24. TA1 generates element tables for use in matrix assembly and stress recovery.
26. Go to DMAP No. 208 and print error message if there are no structural elements.
31. EMG generates structural element matrix tables and dictionaries for later assembly.
34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.
35. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
38. Go to DMAP No. 208 and print error message if no mass matrix is to be assembled.
39. EMA assembles mass matrix $[M_{gg}]$.
41. Go to DMAP No. 44 if no weight and balance request.
42. GPWG generates weight and balance information.
43. ØFP formats weight and balance information and places it on the system output file for printing.
45. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
47. Go to DMAP No. 50 if no general elements.
48. SMA3 adds general elements to stiffness matrix $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
52. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.
57. Go to DMAP No. 62 if general elements present.
58. GPSP determines if possible grid point singularities remain.
60. Go to DMAP No. 62 if no grid point singularities remain.
61. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.
63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

MODAL TRANSIENT RESPONSE

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m^T R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & K_{nm} \\ K_{mn} & K_{mm} \end{bmatrix} \quad \text{and} \quad [M_{gg}] = \begin{bmatrix} \bar{M}_{nn} & M_{nm} \\ M_{mn} & M_{mm} \end{bmatrix}$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & M_{fs} \\ M_{sf} & M_{ss} \end{bmatrix}$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix}$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix.

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & M_{ao} \\ M_{oa} & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$$

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86. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if free-body supports.
88. Go to DMAP No. 92 if no free-body supports.
89. RBMG1 partitions out free-body supports.

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array} \right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array} \right]$$

91. Go to DMAP No. 94.
93. Go to DMAP No. 102 if no request for mode acceleration data recovery.
95. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.
97. Go to DMAP No. 102 if no free-body supports.
98. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}$$

100. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.
103. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Eigenvalue Extraction Data, Dynamic Loads Table, Nonlinear Function Table and Transient Response List.
105. Go to DMAP No. 206 and print error message if no Eigenvalue Extraction Data.
107. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.
110. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

MODAL TRANSIENT RESPONSE

$$[\phi_{ao}] = \begin{bmatrix} D_m \phi_{ro} \\ \phi_{ro} \end{bmatrix},$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

- 1) Unit value of selected coordinate
- 2) Unit value of largest component
- 3) Unit value of generalized mass.

114. ØFP formats the summary of eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.
116. Go to DMAP No. 210 and print error message if no eigenvalues found.
117. MTRXIN selects the direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$ and $[B_{pp}^2]$.
121. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied, and $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points.
123. GKAD applies constraints to direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$ and $[B_{pp}^2]$, forming $[K_{dd}^2]$, $[M_{dd}^2]$ and $[B_{dd}^2]$.
125. GKAM assembles stiffness mass and damping matrices in modal coordinates for use in Transient Response

$$[K_{hh}] = [k] + [\phi_{dh}^T][K_{dd}^2][\phi_{dh}],$$

$$[M_{hh}] = [m] + [\phi_{dh}^T][M_{dd}^2][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi_{dh}^T][B_{dd}^2][\phi_{dh}],$$

where

$$m_i = \text{modal masses}$$

$$b_i = m_i 2\pi f_i g(f_i)$$

$$k_i = m_i 4\pi^2 f_i^2$$

and all matrices are real.

128. Go to DMAP No. 212 and print error message if no Transient Response List.
131. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

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132. Beginning of loop for additional dynamic load sets.
134. CASE extracts user requests from CASECC for current loop.
138. TRLG generates matrices of loads versus time. $\{P_p^t\}$, $\{P_s^t\}$, and $\{P_d^t\}$ are generated with one column per output time step. $\{P_d\}$ and $\{P_h\}$ are generated with one column per solution time step, and the Transient Output List (TOL) is a list of output time steps.
141. Equivalence $\{P_d\}$ to $\{P_d^t\}$ if the output times are the same as the solution times and $\{P_d^t\}$ to $\{P_p^t\}$ if the d and p sets are the same.
143. TRD forms the linear and nonlinear dynamic load vectors $\{P_d\}$ and $\{P_d^{nl}\}$ and integrates the equations of motion over specified time periods to solve for the displacements, velocities and accelerations, using the following equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = \{P_h\} + \{P_h^{nl}\} .$$

146. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).
149. Go to DMAP No. 157 if no output request for the solution points.
150. SDR3 sorts the solution point displacements, velocities, accelerations and nonlinear load vectors by point number.
151. OFP formats the requested solution point displacements, velocities, accelerations and nonlinear load vectors sorted by point number and places them on the system output file for printing.
154. XYTRAN prepares the input for X-Y plotting of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.
156. XYPLT prepares requested X-Y plots of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.
159. Go to DMAP No. 199 if no output request involving dependent degrees of freedom, forces and stresses, or deformed structure plot.
163. DDR1 transforms the solution vector displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\} .$$

165. Go to DMAP No. 170 if mode acceleration technique not requested.
166. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.
171. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.
172. Go to DMAP No. 174 if no constraints applied.

MODAL TRANSIENT RESPONSE

173. SDR1 recovers dependent components of displacements

$$\begin{aligned} \{u_o\} &= [G_o^d]\{u_d\} & \begin{pmatrix} u_d \\ \hline u_o \end{pmatrix} &= \{u_f + u_e\} \\ \begin{pmatrix} u_f + u_e \\ \hline u_s \end{pmatrix} &= \{u_n + u_e\}, & \{u_m\} &= [G_m^d]\{u_n + u_e\} \\ \begin{pmatrix} u_n + u_e \\ \hline u_m \end{pmatrix} &= \{u_p\} \end{aligned}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

176. SDR2 calculates element forces and stresses ($\emptyset EF1$, $\emptyset ES1$) and prepares load vectors, displacement, velocity and acceleration vectors and single-point forces of constraint for output ($\emptyset PP1$, $\emptyset UPV1$, $PUGV$, $\emptyset QP1$) - all sorted by time step.
177. SDR3 prepares requested output sorted by point number or element number.
178. Go to DMAP No. 187 if no mode acceleration requested.
180. SDR1 recovers dependent components of the eigenvectors

$$\begin{aligned} \{\phi_o\} &= [G_o^d]\{\phi_h\}, & \begin{pmatrix} \phi_h \\ \hline \phi_o \end{pmatrix} &= \{\phi_f + u_e\} \\ \begin{pmatrix} \phi_f + u_e \\ \hline \phi_s \end{pmatrix} &= \{\phi_n + u_e\} & \{\phi_m\} &= [G_m^d]\{\phi_n + u_e\} \\ \begin{pmatrix} \phi_n + u_e \\ \hline \phi_m \end{pmatrix} &= \{\phi_g + u_e\} = \{\phi_p\} \end{aligned}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}^T]\{\phi_f\}.$$

181. SDR2 calculates element forces and stresses ($\emptyset EF1$, $\emptyset ES1$) and prepares eigenvectors and single-point forces of constraint for output ($\emptyset PHIP1$, $\emptyset QP1$) - all sorted by time step.
182. SDR2 prepares load vectors for output ($\emptyset PPA$) sorted by time step.
183. SDR3 prepares requested output sorted by point number or element number.

RIGID FORMATS

184. Equivalence ØPPB to ØPP2 if mode acceleration requested.
185. DDRMM prepares a subset of the element forces and stresses (ZEF2, ZES2), and displacement vectors and single-point forces of constraint (ZUPV2, ZQP2) solutions for output by point number or element number sort.
186. Equivalence ZUPV2 to ØUPV2, ZQP2 to ØQP2, ZES2 to ØES2, and ZEF2 to ØEF2 if mode acceleration requested.
189. ØFP formats requested output sorted by point number or element number and places it on the system output file for printing.
191. Go to DMAP No. 195 if no deformed structure plots requested.
192. PLØT prepares all requested deformed structure plots.
194. PRMSG prints plotter data and engineering data for each deformed plot generated.
196. XYTRAN prepares the input for requested X-Y plots.
198. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs time.
200. Go to DMAP No. 214 if no additional dynamic load sets need to be processed.
201. Go to DMAP No. 132 if additional dynamic load sets need to be processed.
202. Go to DMAP No. 204 and print error message if more than 100 loops.
203. Go to DMAP No. 214 and make normal exit.
205. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.
207. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.
209. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATION.
211. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATION.
213. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 5 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIONS.

MODAL TRANSIENT RESPONSE

3.13.3 Automatic Output for Modal Transient Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.13.4 Case Control Deck and Parameters for Modal Transient Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Transient Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Transient Response. Output for SØLUTION points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTION points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

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2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.
3. C0UPMASS - CPBAR, CPR0D, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
4. LFREQ and HFREQ - required unless LM0DES is used. The values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.
5. LM0DES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.
6. M0DACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

3.14 NORMAL MODES WITH DIFFERENTIAL STIFFNESS

3.14.1 DMAP Sequence for Normal Modes with Differential Stiffness

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 13

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NO.13 NORMAL MODES WITH DIFFERENTIAL STIFFNESS - SERIES N $
2 FILE       LAMA=APPEND/PHIA=APPEND $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL/V,N,LUSET/  V,N,
              NOGPD,T $
4 SAVE       LUSET $
5 CHKPNT     GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL $
6 GP2        GEOM2,EQEXIN/ECT $
7 CHKPNT     ECT $
8 PARAML     PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
9 PURGE      PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
10 COND      P1,NOPCDB $
11 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
              JUMPPLOT=-1 $
12 SAVE      NSIL,JUMPPLOT $
13 PRTMSG     PLTSETX// $
14 PARAM      //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
15 PARAM      //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
16 COND      P1,JUMPPLOT $
17 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPD,T,EQEXIN,SIL,,,/PLOTX1/  V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
18 SAVE      JUMPPLOT,PLTFLG,PFILE $
19 PRTMSG     PLOTX1// $
20 LABEL     P1 $
21 CHKPNT     PLTPAR,GPSETS,ELSETS $
22 GP3        GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $
23 CHKPNT     SLT,GPTT $
24 TA1        ECT,EPT,BGPD,T,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/  V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
25 SAVE      NOSIMP,NOGENL,GENEL $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

26	COND	ERROR1,VOSIMP \$
27	PURGE	OGPST/GENEL \$
28	CHKPNT	EST,GPECT,GEI,OGPST \$
29	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
30	EMG	EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V, N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
31	SAVE	NOKGGX,NOMGG \$
32	CHKPNT	KELM,KDICT,MELM,MDICT \$
33	COND	JMPKGG,NOKGGX \$
34	EMA	GPECT,KDICT,KELM/KGGX,GPST \$
35	CHKPNT	KGGX,GPST \$
36	LABEL	JMPKGG \$
37	COND	ERROR5,NOMGG \$
38	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
39	CHKPNT	MGG \$
40	COND	LBL1,GRDPNT \$
41	GPWG	BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS \$
42	OFF	OGPWG,,,,// \$
43	LABEL	LBL1 \$
44	EQUIV	KGGX,KGG/NOGENL \$
45	CHKPNT	KGG \$
46	COND	LBL11,NOGENL \$
47	SMA3	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$
48	CHKPNT	KGG \$
49	LABEL	LBL11 \$
50	PARAM	//C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 \$
51	GP4	CASECC,GEOM4,EQEXIN,SIL,GPD,T,BGPDT,CSTM/RG,YS,USET,ASET/V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 13

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

52	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA \$
53	COND	ERRJR6,NOL \$
54	PARAM	//C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT \$
55	PURGE	GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS/SINGLE/ QG/ NOSR \$
56	CHKPNT	GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,QG \$
57	COND	LBL4D,REACT \$
58	JUMP	ERROR2 \$
59	LABEL	LBL4D \$
60	COND	LBL4,GENEL \$
61	GPSP	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
62	SAVE	NOGPST \$
63	COND	LBL4,NOGPST \$
64	OFF	OGPST,,,,,// \$
65	LABEL	LBL4 \$
66	EQUIV	KGG,KNN/MPCF1 \$
67	CHKPNT	KNN \$
68	COND	LBL2,MPCF2 \$
69	MCE1	USET,RG/GM \$
70	CHKPNT	GM \$
71	MCE2	USET,GM,KGG,,,/KNN,,, \$
72	CHKPNT	KNN \$
73	LABEL	LBL2 \$
74	EQUIV	KNN,KFF/SINGLE \$
75	CHKPNT	KFF \$
76	COND	LBL3,SINGLE \$
77	SCE1	USET,KNN,,,/KFF,KFS,KSS,,, \$
78	CHKPNT	KFS,KSS,KFF \$
79	LABEL	LBL3 \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 13

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

80	EQUIV	KFF,KAA/OMIT \$
81	CHKPNT	KAA \$
82	COND	LBL5,OMIT \$
83	<u>SMP1</u>	USET,KFF,,,/GO,KAA,KOO,LOO,,,, \$
84	CHKPNT	GO,KAA,KOO,LOG \$
85	LABEL	LBL5 \$
86	<u>RBMG2</u>	KAA/LLL \$
87	CHKPNT	LLL \$
88	<u>SSG1</u>	SLT,BGPD,T,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/ V,N, LUSET/C,N,1 \$
89	CHKPNT	PG \$
90	EQUIV	PG,PL/NOSET \$
91	CHKPNT	PL \$
92	COND	LBL10,NOSET \$
93	<u>SSG2</u>	USET,GM,YS,KFS,GO,,PG/,PO,PS,PL \$
94	CHKPNT	PO,PS,PL \$
95	LABEL	LBL10 \$
96	<u>SSG3</u>	LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/ C,N,1/V,N,EPSI \$
97	SAVE	EPSI \$
98	CHKPNT	ULV,UOOV,RULV,RUOV \$
99	COND	LBL9,IRES \$
100	MATGPR	GPL,USET,SIL,RULV//C,N,L \$
101	MATGPR	GPL,USET,SIL,RUOV//C,N,O \$
102	LABEL	LBL9 \$
103	<u>SDR1</u>	USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N, BKLO \$
104	CHKPNT	UGV,QG,PGG \$
105	<u>SDR2</u>	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPD,T,,QG,UGV,EST,,PGG/ QPG1,QQG1,UGV1,OES1,QEF1,PUGV1/C,N,BKLO \$

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 13

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

106	PARAM	//C,N,MPY/V,N,CARDNO/C,N,O/C,N,O \$
107	OFF	OUGV1,OPG1,OQG1,DEF1,OES1,//V,N,CARDNO \$
108	SAVE	CARDNO \$
109	COND	P2,JUMPPLOT \$
110	PLOT	PLTPAR,GPSETS,ELSETS,CASECC,BGPD,T,EQEXIN,SIL,PUGV1,,GPECT,OES1/ PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
111	SAVE	PFILE \$
112	PRMSG	PLOTX2// \$
113	LABEL	P2 \$
114	TA1	ECT,EPT,BGPD,T,SIL,GPDT,CSTM/X1,X2,ECPT,GPCT/V,N,LUSET/ V,N, NOSIMP/C,N,O/V,N,NOGENL/V,N,GENEL \$
115	DSMG1	CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/ V,N, DSC0SET \$
116	SAVE	DSC0SET \$
117	CHKPNT	KDGG \$
118	EQUIV	KDGG,KDNN/MPCF2 / MGG,MNN/MPCF2 \$
119	CHKPNT	KDNN,MNN \$
120	COND	LBL2D,MPCF2 \$
121	MCE2	USET,GM,KDGG,MGG,,/KDNN,MNN,, \$
122	CHKPNT	KDNN,MNN \$
123	LABEL	LBL2D \$
124	EQUIV	KDNN,KDFF/SINGLE / MNN,MFF/SINGLE \$
125	CHKPNT	KDFF,MFF \$
126	COND	LBL3D,SINGLE \$
127	SCE1	USET,KDNN,MNN,,/KDFF,KDFS,KDSS,MFF,, \$
128	CHKPNT	KDFF,KDFS,KDSS,MFF \$
129	LABEL	LBL3D \$
130	EQUIV	KDFF,KDAA/OMIT / MFF,MAA/OMIT \$
131	CHKPNT	KDAA,MAA \$
132	COND	LBL5D,OMIT \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 13

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

133	(SMP2)	USET,GO,KDFF/KDAA \$
134	(SMP2)	USET,GO,MFF/MAA \$
135	CHKPNT	KDAA,MAA \$
136	LABEL	LBL5D \$
137	EQUIV	PL,PBL/DSCASET/PS,PBS/DSCASET/YS,YBS/DSCASET/UQOV,UBQOV/ DSCASET \$
138	CHKPNT	PBL,PBS,YBS,UBQOV \$
139	PARAM	//C,N,MPY/V,N,NDSKIP/C,N,O/C,N,O \$
140	(DSMG2)	MPT,KAA,KDAA,KFS,KDFS,KSS,KDSS,PL,PS,YS,UQOV/KBLL,KBFS,KBSS, PBL,PBS,YBS,UBQOV/V,N,NDSKIP/ V,N,REPEATD/ V,N,DSCASET \$
141	SAVE	NDSKIP,REPEATD \$
142	CHKPNT	KBLL,KBFS,KBSS,PBL,PBS,YBS,UBQOV \$
143	(RBMG2)	KBLL/LBLL/V,N,POWER/V,N,DET \$
144	SAVE	DET,POWER \$
145	CHKPNT	LBLL \$
146	PRTPARM	//C,N,O/C,N,DET \$
147	PRTPARM	//C,N,O/C,N,POWER \$
148	(SSG3)	LBLL,KBLL,PBL,,,/UBLV,,RUBLV,/C,N,-1/V,Y,IRES/V,N,NDSKIP/ V,N, EPSI \$
149	SAVE	EPSI \$
150	CHKPNT	UBLV,RUBLV \$
151	COND	LBL9D,IRES \$
152	MATGPR	GPL,USET,SIL,RUBLV//C,N,L \$
153	LABEL	LBL9D \$
154	(SDR1)	USET,,UBLV,UBQOV,YBS,GO,GM,PBS,KBFS,KBSS,/UBGV,,QBG/V,N,NDSKIP/ C,N,DS1 \$
155	CHKPNT	UBGV,QBG \$
156	(SDR2)	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPD,,QBG,UBGV,EST,,/, QBG1,UBGV1,OESB1,DEFB1,PUBGV1/C,N,DS1 \$
157	DFP	QBG1,UBGV1,OESB1,DEFB1,,//V,N,CARDNO \$
158	(DPD)	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USED,,,,,,,,EED,EQOYN/V,N,

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 13

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
N,NONLFT/V,N,NUTRL/V,N,NOEED/C,N,/V,N,NOUE \$

159 SAVE NOEED \$

160 COND ERROR3,NOEED \$

161 CHKPNT EED \$

162 PARAM //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 \$

163 READ KBLL,MAA,,,EED,USECC/LAMA,PHIA,,OEIGS/C,N,MODES/ V,N,
NEIGV/C,N,3 \$

164 SAVE NEIGV \$

165 CHKPNT LAMA,PHIA,OEIGS \$

166 OFP OEIGS,LAMA,,,,//V,N,CARDNO \$

167 SAVE CARDNO \$

168 COND ERRDR4,NEIGV \$

169 SDR1 USECC,,PHIA,,,GO,GM,,KDFS,,/PHIG,,BQG/C,N,1/C,N,REIG \$

170 CHKPNT PHIG,BQG \$

171 CASE CASECC,/CASEXX/C,N,TRANRESP/V,N,KEPEAT=3/V,N,LOOP \$

172 SDR2 CASEXX,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,BQG,PHIG,EST,,/
OBQG1,OPHIG,OBES1,OBEL1,PPHIG/C,N,REIG \$

173 OFP OPHIG,OBQG1,OBEL1,OBES1,,//V,N,CARDNO \$

174 SAVE CARDNO \$

175 COND P3,JUMPPLOT \$

176 PLOT PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,PPHIG,GPECT,
JBES1/PLDTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
PFILE \$

177 SAVE PFILE \$

178 PRTMSG PLOTX3// \$

179 LABEL P3 \$

180 JUMP FINIS \$

181 LABEL ERROR1 \$

182 PRTPARM //C,N,-1/C,N,NMDS \$

183 LABEL ERROR2 \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 13

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

184 PRTPARM //C,N,-2/C,N,NMDS \$
185 LABEL ERROR3 \$
186 PRTPARM //C,N,-3/C,N,NMDS \$
187 LABEL ERROR4 \$
188 PRTPARM //C,N,-4/C,N,NMDS \$
189 LABEL ERROR5 \$
190 PRTPARM //C,N,-5/C,N,NMDS \$
191 LABEL ERROR6 \$
192 PRTPARM //C,N,-5/C,N,NMDS \$
193 LABEL FINIS \$
194 END \$

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

3.14.2 Description of DMAP Operations for Normal Modes with Differential Stiffness.

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
6. GP2 generates Element Connection Table with internal indices.
10. Go to DMAP No. 20 if no plot package is present.
11. PLTSET transforms user input into a form used to drive structure plotter.
13. PRTMSG prints error messages associated with structure plotter.
16. Go to DMAP No. 20 if no undeformed structure plot request.
17. PLØT generates all requested undeformed structure plots.
19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
22. GP3 generates Static Loads Table and Grid Point Temperature Table.
24. TAI generates element tables for use in matrix assembly and stress recovery.
26. Go to DMAP No. 181 and print error message if no elements have been defined.
30. EMG generates structural element matrix tables and dictionaries for later assembly.
33. Go to DMAP No. 36 if no stiffness matrix is to be assembled.
34. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
37. Go to DMAP No. 189 and print error message if no mass matrix exists.
38. EMA assembles mass matrix $[M_{gg}]$.
40. Go to DMAP No. 43 if no weight and balance request.
41. GPWG generates weight and balance information.
42. ØFP formats weight and balance information and places it on the system output file for printing.
44. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
46. Go to DMAP No. 49 if no general elements.
47. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
51. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.
53. Go to DMAP No. 191 and print error message if no independent degrees of freedom are defined.
57. Go to DMAP No. 59 if no support cards.
58. Go to DMAP No. 183 and print error message if free-body supports are present.
60. Go to DMAP No. 65 if general elements present.
61. GPSP determines if possible grid point singularities remain.
63. Go to DMAP No. 65 if no grid point singularities remain.

RIGID FORMATS

64. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.
66. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.
68. Go to DMAP No. 73 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
69. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
71. MCE2 partitions stiffness matrix

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & | & K_{nm} \\ \hline K_{mn} & | & K_{mm} \end{bmatrix}$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

74. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.
76. Go to DMAP No. 79 if no single-point constraints.
77. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & | & K_{fs} \\ \hline K_{sf} & | & K_{ss} \end{bmatrix}$$

80. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.
82. Go to DMAP No. 85 if no omitted coordinates.
83. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & | & K_{ao} \\ \hline K_{oa} & | & K_{oo} \end{bmatrix}$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

86. RBMG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$.
88. SSG1 generates static load vectors $\{P_g\}$.

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

90. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

92. Go to DMAP No. 95 if no constraints applied.

93. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ - \\ P_m \end{Bmatrix}, \quad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ - \\ P_s \end{Bmatrix}, \quad \{P_f\} = \{\bar{P}_f\} + [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ - \\ P_o \end{Bmatrix} \text{ and } \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\}.$$

96. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\},$$

solves for displacements of omitted coordinates

$$\{u_o^0\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\epsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}},$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^0\},$$

$$\epsilon_o = \frac{\{u_o^0^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^0\}}$$

99. Go to DMAP No. 102 if residual vectors are not to be printed.

100. Print residual vector for independent coordinates (RULV).

RIGID FORMATS

101. Print residual vector for omitted coordinates (RUØV).

103. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^0\} ,$$

$$\begin{Bmatrix} u_a \\ u_o \end{Bmatrix} = \{u_f\} ,$$

$$\begin{Bmatrix} u_f \\ y_s \end{Bmatrix} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\} ,$$

$$\begin{Bmatrix} u_n \\ u_m \end{Bmatrix} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{y_s\} .$$

- 105. SDR2 calculates element forces and stresses (ØEF1, ØES1) and prepares load vectors, displacement vectors and single-point forces of constraint for output (ØPG1, ØUGV1, PUGV1, ØQG1).
- 107. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.
- 109. Go to DMAP No. 113 if no static deformed structure plots are requested.
- 110. PLØT generates all requested static deformed structure plots.
- 112. PRTMSG prints plotter data and engineering data for each deformed plot generated.
- 114. TA1 generates element tables for use in matrix assembly for differential stiffness matrix.
- 115. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.
- 118. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.
- 120. Go to DMAP No. 123 if no multipoint constraints.
- 121. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \begin{bmatrix} \bar{K}_{nn}^d & | & K_{nm}^d \\ \hline K_{mn}^d & | & K_{mm}^d \end{bmatrix}$$

and performs matrix reduction

$$[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m] .$$

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

124. Equivalence $[K_{nn}^d]$ to $[K_{ff}^d]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

126. Go to DMAP No. 129 if no single-point constraints.

127. SCE1 partitions out single-point constraints

$$[K_{nn}^d] = \begin{bmatrix} K_{ff}^d & | & K_{fs}^d \\ \hline K_{sf}^d & | & K_{ss}^d \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & | & M_{fs} \\ \hline M_{sf} & | & M_{ss} \end{bmatrix}$$

130. Equivalence $[K_{ff}^d]$ to $[K_{aa}^d]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

132. Go to DMAP No. 136 if no omitted coordinates.

133. SMP2 partitions constrained differential stiffness matrix

$$[K_{ff}^d] = \begin{bmatrix} \bar{K}_{aa}^d & | & K_{ao}^d \\ \hline K_{oa}^d & | & K_{oo}^d \end{bmatrix}$$

and performs matrix reduction $[K_{aa}^d] = [\bar{K}_{aa}^d] + [K_{ao}^d][G_o]$.

134. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & | & M_{ao} \\ \hline M_{oa} & | & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$$

137. Equivalence $\{P_\ell\}$ to $\{P_\ell^b\}$, $\{P_s\}$ to $\{P_s^b\}$, $\{Y_s\}$ to $\{Y_s^b\}$ and $\{u_o^0\}$ to $\{u_o^{ob}\}$ if no scale factors are specified on a DSFACT card.

140. DSMG2 adds partitions of stiffness matrix to similar partitions of differential stiffness matrix

$$[K_{\ell\ell}^b] = [K_{aa}] + \beta[K_{aa}^d]$$

$$[K_{fs}^b] = [K_{fs}] + \beta[K_{fs}^d] \quad \text{and}$$

$$[K_{ss}^b] = [K_{ss}] + \beta[K_{ss}^d]$$

RIGID FORMATS

and multiplies partitions of load vectors and displacement vectors by current value of differential stiffness scale factor (β)

$$\begin{aligned} \{P_\ell^b\} &= \beta \{P_\ell\} \quad , & \{P_s^b\} &= \beta \{P_s\} \quad , \\ \{Y_s^b\} &= \beta \{Y_s\} \quad \text{and} \quad , & \{u_0^{bo}\} &= \beta \{u_0^o\} \quad . \end{aligned}$$

143. RBMG2 decomposes the combined differential stiffness matrix and elastic stiffness matrix

$$[K_{\ell\ell}^b] = [L_{\ell\ell}^b][U_{\ell\ell}^b] \quad .$$

146. PRTPARM prints the scaled value of the determinant of the combined differential stiffness matrix and elastic stiffness matrix.
147. PRTPARM prints the scale factor (power of ten) of the determinant of the combined differential stiffness matrix and the elastic stiffness matrix.
148. SSG3 solves for displacements of independent coordinates for current value of differential stiffness scale factor (β)

$$\{u_\ell^b\} = [K_{\ell\ell}^b]^{-1} \{P_\ell^b\}$$

and calculates residual vector (RBULV) and residual vector error ratio for current value of differential stiffness load factor

$$\{\delta P_\ell^b\} = \{P_\ell^b\} - [K_{\ell\ell}^b] \{u_\ell^b\} \quad ,$$

$$\epsilon_\ell^b = \frac{\{u_\ell^b\}^T \{\delta P_\ell^b\}}{\{P_\ell^b\}^T \{u_\ell^b\}}$$

151. Go to DMAP No. 153 if residual vector for current value of differential stiffness load factor is not to be printed.
152. Print residual vector for current value of differential stiffness load factor.
154. SDR1 recovers dependent displacements for current value of differential stiffness scale factor

$$\{u_0^b\} = [G_0] \{u_\ell^b\} + \{u_0^{ob}\} \quad , \quad \begin{pmatrix} u_\ell^b \\ u_0^b \end{pmatrix} = \{u_f^b\} \quad ,$$

$$\begin{pmatrix} u_f^b \\ y_s^b \end{pmatrix} = \{u_n^b\} \quad ,$$

$$\{u_m^b\} = [G_m] \{u_n^b\} \quad ,$$

$$\begin{pmatrix} u_n^b \\ u_m^b \end{pmatrix} = \{u_g^b\}$$

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

and recovers single-point forces of constraint for current value of differential stiffness scale factor

$$\{q_s^b\} = -\{P_s^b\} + [K_{sf}^b]\{u_f^b\} + [K_{ff}^b]\{Y_s^b\} .$$

156. SDR2 calculates element forces and stresses (ØEFB1, ØESB1) and prepares displacement vectors and single-point forces of constraint for output (ØUBGV1, PUBGV1, ØQBG1) .
157. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.
158. DPD extracts Eigenvalue Extraction Data from Dynamics data block.
160. Go to DMAP No. 185 and print error message if no Eigenvalue Extraction Data.
163. READ extracts real eigenvalues from the equation

$$[K_{\ell\ell}^b - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized, computes rigid body eigenvectors

$$[\phi_{ao}] = \frac{D \phi_{ro}}{\phi_{ro}}$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

- 1) Unit value of selected coordinate
- 2) Unit value of largest component
- 3) Unit value of generalized mass.

166. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.
168. Go to DMAP No. 187 and exit if no eigenvalues found.
169. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} , \quad \left\{ \begin{array}{c} \phi_a \\ \hline \phi_o \end{array} \right\} = \{\phi_f\} ,$$

$$\left\{ \begin{array}{c} \phi_f \\ \hline \phi_s \end{array} \right\} = \{\phi_n\} , \quad \{\phi_m\} = [G_m]\{\phi_n\} ,$$

RIGID FORMATS

$$\begin{Bmatrix} \phi_n \\ \phi_m \end{Bmatrix} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [k_{fs}^T]\{\phi_f\}$.

172. SDR2 calculates element forces and stresses (ØBEF1, ØBES1) and prepares eigenvectors and single-point forces of constraint for output (ØPHIG, PPHIG, ØBQG1).
173. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.
175. Go to DMAP No. 179 if no deformed real eigenvalue structure plots are requested.
176. PLØT generates all requested deformed real eigenvalue structure plots.
178. PRTMSG prints plotter data and engineering data for each deformed plot generated.
180. Go to DMAP No. 193 and make normal exit.
182. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.
184. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 2 - FREE BØDY SUPPØRTS NØT ALLOWED.
186. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 3 - EIGENVALUE EXTRACTION DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.
188. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 4 - NØ EIGENVALUE FØUND.
190. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 5 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.
192. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

3.14.3 Automatic Output for Normal Modes with Differential Stiffness

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
 - (1) Two consecutive singularities encountered while performing triangular decomposition.
 - (2) Four shift points while tracking a single root.
 - (3) All eigenvalues found in the frequency range specified.
 - (4) Three times the number of roots estimated in the frequency range have been extracted.
 - (5) All eigenvalues that exist in the problem have been found.
 - (6) The number of roots desired have been found.
 - (7) One or more eigenvalues have been found outside the frequency range specified.
 - (8) Insufficient time to find another root.
 - (9) Unable to converge.
7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

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1. Number of eigenvalues extracted.
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Reason for termination.
 - (1) The number of roots desired have been found.
 - (2) All predictions for eigenvalues are outside the frequency range specified.
 - (3) Insufficient time to find another root.
 - (4) Matrix is singular at first three starting points.
8. Largest off-diagonal modal mass term and the number failing the criterion.
9. Swept determinant function for each starting point.

The following summary of the eigenvalue analysis performed using the Givens method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of eigenvectors computed.
3. Number of eigenvalue convergency failures.
4. Number of eigenvector convergence failures.
5. Reason for termination.
 - (1) Normal termination.
 - (2) Insufficient time to calculate eigenvalues and number of eigenvectors requested.
 - (3) Insufficient time to find additional eigenvectors.
6. Largest off-diagonal modal mass term and the number failing the criterion.

The value of the determinant of the sum of the elastic stiffness and the differential stiffness is automatically printed.

3.14.4 Case Control Deck and Parameters for Normal Modes with Differential Stiffness

The following items relate to subcase definition and data selection for Normal Modes with Differential Stiffness:

NORMAL MODES WITH DIFFERENTIAL STIFFNESS

1. The Case Control Deck must contain three subcases. The first subcase is used only for output selection for the linear case.
2. DSCOEFFICIENT must appear in the second subcase, either to select a DSFACT set from the Bulk Data Deck, or to explicitly select the default value of unity.
3. METHOD must appear above the subcase level to select an EIGR bulk data card.
4. The static differential stiffness solution is output from the second subcase. The eigenvector solution is output from the third subcase.
5. A static loading condition must be defined above the subcase level with a LOAD, TEMPERATURE(LOAD), or DEFORM selection, unless all loading is specified by grid point displacements on SPC cards.
6. An SPC set must be selected above the subcase level unless all constraints are specified on GRID cards.

The following output may be requested for Normal Modes with Differential Stiffness:

1. Nonzero components of the applied static load for the linear solution at selected grid points.
2. Displacement and nonzero components of the single-point forces of constraint, with and without differential stiffness, at selected grid points.
3. Forces and stresses in selected elements, with and without differential stiffness.
4. Deformed and undeformed plots.

The following output may be requested for the Normal Mode Analysis subcase:

1. Eigenvectors along with the associated eigenvalue for each mode.
2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.
3. Forces and stresses in selected elements for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected modes.

The following parameters are used in Normal Mode Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

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2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.
3. C0UPMASS - CPBAR, CPR0D, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPODPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of couples mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

STATIC ANALYSIS USING CYCLIC SYMMETRY

3.15 STATIC ANALYSIS USING CYCLIC SYMMETRY

3.15.1 DMAP Sequence for Static Analysis Using Cyclic Symmetry

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 14

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NO.14 STATIC ANALYSIS WITH CYCLIC SYMMETRY - SERIES N      $
2 FILE       KKK=SAVE/PK=SAVE $
3 FILE       UXV=APPEND $
4 PARAM      //C,N,NOP/V,Y,CYCID=1 $
5 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
              VJGPDT $
6 SAVE       LUSET $
7 CHKPNP     GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
8 GP2        GEOM2,EQEXIN/ECT $
9 CHKPNP     ECT $
10 PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
11 PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
12 COND      P1,NOPCDB $
13 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
              JUMPPLOT=-1 $
14 SAVE      NSIL,JUMPPLOT $
15 PRTMSG    PLTSETX// $
16 PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
17 PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
18 COND      P1,JUMPPLOT $
19 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,,/PLOTX1/  V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
20 SAVE      JUMPPLOT,PLTFLG,PFILE $
21 PRTMSG    PLTJTX1// $
22 LABEL     P1 $
23 CHKPNP     PLTPAR,GPSETS,ELSETS $
24 GP3        GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $
25 SAVE      NOGRAV $
26 PARAM     //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GROPNT=-1 $

```

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RIGID FORMAT DMAP LISTING SERIES N

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

27	CHKPNT	SLT,GPTT \$	
28	TA1	ECT,EPT,BGPD,T,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/	V,N, NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL \$
29	SAVE	NOSIMP,NOGENL,GENEL \$	
30	PARAM	//C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP \$	
31	COND	ERROR4,NOELMT \$	
32	PURGE	GPST/NOSIMP/OGPST/GENEL \$	
33	CHKPNT	EST,GPECT,GEI,GPST,OGPST \$	
34	COND	LBL1,NOSIMP \$	
35	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$	
36	EMG	EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/	V, N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/ C,Y,CPTUBE/C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
37	SAVE	NOKGGX,NOMGG \$	
38	CHKPNT	KELM,KDICT,MELM,MDICT \$	
39	COND	JMPKGG,NOKGGX \$	
40	EMA	GPECT,KDICT,KELM/KGGX,GPST \$	
41	CHKPNT	<GGX,GPST \$	
42	LABEL	JMPKGG \$	
43	COND	JMPMGG,NOMGG \$	
44	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$	
45	CHKPNT	MGG \$	
46	LABEL	JMPMGG \$	
47	COND	LBL1,GRDPNT \$	
48	COND	ERROR2,NOMGG \$	
49	GPWG	BGPD,T,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS \$	
50	DFP	OGPWG,,,,,// \$	
51	LABEL	LBL1 \$	
52	EQUIV	KGGX,KGG/NOGENL \$	

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RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 14

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

53	CHKPNT	KGG \$
54	COND	LBL11A,NOGENL \$
55	<u>SMA3</u>	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$
56	CHKPNT	KGG \$
57	LABEL	LBL11A \$
58	PARAM	//C,N,MPY/V,N,NSKIP/C,N,O/C,N,O \$
59	<u>GP4</u>	CASECC,GEUM4,EQEXIN,SIL,GPD,T,BGPD,T,CSTM/RG,YS,USET,ASET/V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
60	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA \$
61	COND	ERRDR3,NOL \$
62	PARAM	//C,N,NOT/V,N,REACDATA/V,N,REACT \$
63	COND	ERRDR5,REACDATA \$
64	PURGE	GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS,QG/SINGLE \$
65	CHKPNT	GM,GO,KOO,LOO,PG,UOOV,RUOV,PS,KFS,KSS,QG,USET,RG,YS,ASET \$
66	<u>GPCYC</u>	GEOM4,EQEXIN,USET/CYCD/V,Y,CTYPE/V,N,NOGO \$
67	SAVE	NOGO \$
68	CHKPNT	CYCD \$
69	COND	ERRDR4,NOGO \$
70	COND	LBL4,GENEL \$
71	<u>GPSP</u>	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
72	SAVE	NOGPST \$
73	COND	LBL4,NOGPST \$
74	DFP	OGPST,,,,,// \$
75	LABEL	LBL4 \$
76	EQUIV	KGG,KNN/MPCF1 \$
77	CHKPNT	KNN \$
78	COND	LBL2,MPCF2 \$
79	<u>MCE1</u>	USET,RG/GM \$

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RIGID FORMAT 14

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

80	CHKPNT	GM \$
81	MCE2	USET,GM,KGG,,,/KNN,,, \$
82	CHKPNT	KNN \$
83	LABEL	LBL2 \$
84	EQUIV	KNN,KFF/SINGLE \$
85	CHKPNT	KFF \$
86	COND	LBL3,SINGLE \$
87	SCE1	USET,KNN,,,/KFF,KFS,KSS,,, \$
88	CHKPNT	KFS,KSS,KFF \$
89	LABEL	LBL3 \$
90	EQUIV	KFF,KAA/OMIT \$
91	CHKPNT	KAA \$
92	COND	LBL5,OMIT \$
93	SMP1	USET,KFF,,,/GO,KAA,KOO,LOO,,,, \$
94	CHKPNT	GO,KAA,KOO,LOO \$
95	LABEL	LBL5 \$
96	SSG1	SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N, LUSET/V,N,NSKIP \$
97	CHKPNT	PG \$
98	EQUIV	PG,PL/NOSET \$
99	CHKPNT	PL \$
100	COND	LBL9,NOSET \$
101	SSG2	USET,GM,YS,KFS,GO,,PG/,PO,PS,PL \$
102	CHKPNT	PO,PS,PL \$
103	COND	LBL9,OMIT \$
104	SSG3	LOO,KOO,PO,,,/UOOV,,RUOV,/C,N,-1/V,Y,IRES=-1 \$
105	CHKPNT	UOOV,RUOV \$
106	COND	LBL9,IRES \$
107	MATGPR	GPL,USET,SIL,RUOV//C,N,O \$

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DMAP-DMAP INSTRUCTION
NO.

108	LABEL	LBL9 \$	
109	EQUIV	PL,PX/CYCIO \$	
110	COND	LBL10,CYCIO \$	
111	CYCT1	PL/PX,GCYCF/V,Y,CTYPE/C,N,FORE/V,Y,NSEGS=-1/V,Y,KMAX=-1/V,Y, NLOAD=1/V,N,NOGO \$	
112	SAVE	KMAX,NOGO \$	
113	LABEL	LBL10 \$	
114	CHKPNT	PX \$	
115	COND	ERROR6,NOGO \$	
116	PARAM	//C,N,ADD/V,N,KINDEX/C,N,0/C,N,0 \$	
117	JUMP	LBL11 \$	
118	LABEL	LBL11 \$	Top of DMAP Loop
119	CYCT2	CYCD,KAA,,PX,,/KKK,,PK,,/C,N,FORE/V,Y,NSEGS/V,N,KINDEX/V,Y, CYCSEQ=-1/V,Y,NLOAD/V,N,NOGO \$	
120	SAVE	NOGO \$	
121	CHKPNT	KKK,PK \$	
122	COND	ERROR6,NOGO \$	
123	RBMG2	KKK/LKK \$	
124	CHKPNT	LKK \$	
125	SSG3	LKK,KKK,PK,,/UKV,,RUKV,/C,N,-1/V,Y,IRES \$	
126	CHKPNT	UKV,RUKV \$	
127	CYCT2	CYCD,,,UKV,RUKV,,/UXV,RUXV,/C,N,BACK/V,Y,NSEGS/V,N,KINDEX/ V,Y,CYCSEQ/V,Y,NLOAD/V,N,NOGO \$	
128	SAVE	NOGO \$	
129	CHKPNT	UXV,RUXV \$	
130	COND	ERROR6,NOGO \$	
131	COND	LBL14,IRES \$	
132	MATGPR	GPL,USET,SIL,RUXV//C,N,A \$	
133	LABEL	LBL14 \$	
134	PARAM	//C,N,ADD/V,N,KINDEX/V,N,KINDEX/C,N,1 \$	

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N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

135	PARAM	//C,N,SUB/V,N,DONE/V,Y,KMAX/V,N,KINDEX \$	
136	COND	LBL15,DONE \$	
137	REPT	LBL11,100 \$	
138	JUMP	ERROR1 \$	Bottom of DMAP Loop
139	LABEL	LBL15 \$	
140	EQUIV	UXV,ULV/CYCIO \$	
141	COND	LBL16,CYCIO \$	
142	CYCT1	UXV/ULV,GCYCB/V,Y,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/V,Y,NLOAD/ V,N,NOGO \$	
143	SAVE	NOGO \$	
144	COND	ERROR6,NOGO \$	
145	LABEL	LBL16 \$	
146	CHKPNT	ULV \$	
147	SDR1	USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/V,N,NSKIP/C,N, STATICS \$	
148	CHKPNT	UGV,PGG,QG \$	
149	SDR2	CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPD,.,QG,UGV,EST,.,PGG/ OPG1,OQG1,OUGV1,OES1,DEF1,PUGV1/C,N,STATICS \$	
150	PARAM	//C,N,MPY/V,N,CARDNO/C,N,O/C,N,O \$	
151	OPF	OUGV1,OPG1,OQG1,DEF1,OES1,./V,N,CARDNO \$	
152	SAVE	CARDNO \$	
153	COND	P2,JUMPPLOT \$	
154	PLOT	PLTPAR,GPSETS,ELSETS,CASECC,BGPD,.,EQEXIN,SIL,PUGV1,.,GPECT,OES1/ PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$	
155	SAVE	PFILE \$	
156	PRTMSG	PLOTX2// \$	
157	LABEL	P2 \$	
158	JUMP	FINIS \$	
159	LABEL	ERROR1 \$	
160	PRTPARM	//C,N,-1/C,N,CYCSTATICS \$	

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DMAP-DMAP INSTRUCTION
NO.

161 LABEL ERROR2 \$
162 PRTPARM //C,N,-2/C,N,CYCSTATICS \$
163 LABEL ERROR3 \$
164 PRTPARM //C,N,-3/C,N,CYCSTATICS \$
165 LABEL ERROR4 \$
166 PRTPARM //C,N,-4/C,N,CYCSTATICS \$
167 LABEL ERROR5 \$
168 PRTPARM //C,N,-5/C,N,CYCSTATICS \$
169 LABEL ERROR6 \$
170 PRTPARM //C,N,-6/C,N,CYCSTATICS \$
171 LABEL FINIS \$
172 END \$

RIGID FORMATS

3.15.2 Description of DMAP Operations for Static Analysis Using Cyclic Symmetry

5. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
8. GP2 generates Element Connection Table with internal indices.
12. Go to DMAP No. 22 if no plot package is present.
13. PLTSET transforms user input into a form used to drive structure plotter.
15. PRTMSG prints error messages associated with structure plotter.
18. Go to DMAP No. 22 if no undeformed structure plot request.
19. PLØT generates all requested undeformed structure plots.
21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
24. GP3 generates Static Loads Table and Grid Point Temperature Table.
28. TA1 generates element tables for use in matrix assembly and stress recovery.
31. Go to DMAP No. 165 and print error message if no elements have been defined.
34. Go to DMAP No. 51 if there are no structural elements.
36. EMG generates structural element matrix tables and dictionaries for later assembly.
39. Go to DMAP No. 42 if no stiffness matrix is to be assembled.
40. EMA assembles stiffness matrix $[K_{gg}^X]$ and Grid Point Singularity Table.
43. Go to DMAP No. 46 if no mass matrix is to be assembled.
44. EMA assembles mass matrix $[M_{gg}]$.
47. Go to DMAP No. 51 if no weight and balance request.
48. Go to DMAP No. 161 and print error message if no mass matrix exists.
49. GPWG generates weight and balance information.
50. ØFP formats weight and balance information and places it on the system output file for printing.
52. Equivalence $[K_{gg}^X]$ to $[K_{gg}]$ if no general elements.
54. Go to DMAP No. 57 if no general elements.
55. SMA3 adds general elements to $[K_{gg}^X]$ to obtain stiffness matrix $[K_{gg}]$.
59. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.
61. Go to DMAP No. 163 and print error message if no independent degrees of freedom are defined.
63. Go to DMAP No. 167 and print error message if free-body supports are present.

STATIC ANALYSIS USING CYCLIC SYMMETRY

66. GPCYC prepares segment boundary table.

69. Go to DMAP No. 165 and print error message if CYJØIN data is inconsistent.

70. Go to DMAP No. 75 if general elements present.

71. GPSP determines if possible grid point singularities remain.

73. Go to DMAP No. 75 if no grid point singularities remain.

74. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.

76. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

78. Go to DMAP No. 83 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

79. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

81. MCE2 partitions stiffness matrix

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & K_{nm} \\ K_{mn} & K_{mm} \end{bmatrix}$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

84. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

86. Go to DMAP No. 89 if no single-point constraints.

87. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ K_{sf} & K_{ss} \end{bmatrix}$$

90. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

92. Go to DMAP No. 95 if no omitted coordinates.

93. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & K_{ao} \\ K_{oa} & K_{oo} \end{bmatrix}$$

RIGID FORMATS

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

96. SSG1 generates static load vectors $\{P_g\}$.

98. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

101. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ - \\ P_m \end{Bmatrix}, \quad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ - \\ P_s \end{Bmatrix}, \quad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \begin{Bmatrix} \bar{P}_a \\ - \\ P_o \end{Bmatrix}, \quad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \begin{Bmatrix} P_\ell \\ - \\ P_r \end{Bmatrix}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

103. Go to DMAP No. 108 if no omitted coordinates.

104. SSG3 solves for displacements of omitted coordinates (these are not transformed)

$$\{u_o^0\} = [K_{oo}]^{-1}\{P_o\},$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^0\},$$

$$\epsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^0\}}.$$

106. Go to DMAP No. 108 if residual vectors are not to be printed.

107. MATGPR prints the residual vector for omitted coordinates (RUØV).

STATIC ANALYSIS USING CYCLIC SYMMETRY

109. Equivalence $\{P_\ell\}$ to $\{P_x\}$ if symmetric components of loads have been input.
110. Go to DMAP No. 113 if symmetric components of loads have been input.
111. CYCT1 transforms loads on analysis points to symmetric components.
115. Go to DMAP No. 169 and print error message if CYCT1 error was found.
117. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.
118. Beginning of loop for cyclic index values (KINDEX).
119. CYCT2 transforms matrices and loads from symmetric components to solution set.
122. Go to DMAP No. 169 and print error message if CYCT2 error was found.
123. RBMG2 decomposes constrained stiffness matrix for solution set.

$$[K_{kk}] = [L_{kk}][u_{kk}]$$

125. SSG3 solves for displacements of solution set coordinates

$$\{u_k\} = [K_{kk}]^{-1}\{P_k\} \quad ,$$

and calculates residual vector (RUKV) and residual vector error ratio for solution set coordinates

$$\{\delta P_k\} = \{P_k\} - [K_{kk}]\{u_k\} \quad ,$$

$$\epsilon_k = \frac{\{u_k^T\}\{\delta P_k\}}{\{P_k^T\}\{u_k\}}$$

127. CYCT2 finds symmetric components of displacement from solution set data, and appends to output for each KINDEX.
130. Go to DMAP No. 169 and print error message if CYCT2 error was found.
131. Go to DMAP No. 133 if residual vectors are not to be printed.
132. MATGPR prints the residual vector for solution set coordinates (RUXV).
136. Go to DMAP No. 139 if all cyclic index (KINDEX) values are complete.
137. Go to DMAP No. 118 if additional index values are needed.

RIGID FORMATS

- 138. Go to DMAP No. 159 and print error message if number of loops exceeds 100.
- 140. Equivalence $\{u_x\}$ to $\{u_\ell\}$ if output of symmetric components was requested.
- 141. Go to DMAP No. 145 if output of symmetric components was requested.
- 142. CYCT1 transforms displacements from symmetrical components to physical components.
- 144. Go to DMAP No. 169 and print error message if CYCT1 error was found.
- 147. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_a\} + \{u_o^0\} ,$$

$$\begin{pmatrix} u_a \\ - \\ u_o \end{pmatrix} = \{u_f\} , \quad \begin{pmatrix} u_f \\ - \\ \gamma_s \end{pmatrix} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\} , \quad \begin{pmatrix} u_n \\ - \\ u_m \end{pmatrix} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{\gamma_s\} .$$

- 149. SDR2 calculates element forces and stresses ($\emptyset EF1$, $\emptyset ES1$) and prepares load vectors, displacement vectors and single-point forces of constraint for output ($\emptyset PG1$, $\emptyset UGV1$, $PUGV1$, $\emptyset QG1$).
- 151. $\emptyset FP$ formats tables prepared by SDR2 and places them on the system output file for printing.
- 153. Go to DMAP No. 157 if no deformed structure plots are requested.
- 154. $PL\emptyset T$ generates all requested deformed structure plots.
- 156. $PRTMSG$ prints plotter data and engineering data for each deformed plot generated.
- 158. Go to DMAP No. 171 and make normal exit.
- 160. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 1. ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

STATIC ANALYSIS USING CYCLIC SYMMETRY

- 162. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 2 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.
- 164. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 3 - NO INDEPENDENT DEGREES OF FREEDOM HAVE BEEN DEFINED.
- 166. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 4 - NO ELEMENTS HAVE BEEN DEFINED.
- 168. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 6 - FREE-BODY SUPPORTS NOT ALLOWED.
- 170. STATICS WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 7 - CYCLIC SYMMETRY DATA ERROR.

RIGID FORMATS

3.15.3 Case Control Deck and Parameters for Static Analysis Using Cyclic Symmetry

The following items relate to subcase definition and data selection:

1. A separate group of subcases must be defined for each symmetric segment. For dihedral symmetry, a separate group of subcases are defined for each half.
2. The different loading conditions are defined within each group of subcases. The loads on each symmetric segment and the selected output requests may be independent. The number of loading cases is specified on the PARAM card NL0AD.
3. The SPC and MPC request must appear above the subcase level and may not be changed.
4. An alternate loading method is to define a separate group of subcases for each harmonic index, k. The parameter CYCIO is included and the load components for each index are defined directly within each group for the various loading conditions.

The following printed output, for each loading condition and each symmetric segment or index, may be requested for Static Analysis solutions:

1. Displacements and components of static loads and single-point forces of constraint at selected grid points or scalar points.
2. Forces and stresses in selected elements.

The following plotter output may be requested for Static Analysis solutions:

1. Undeformed and deformed plots of the structural model (1 segment).
2. X-Y plot of any component of displacement, static load, or single-point force of constraint for a grid point or scalar point.
3. X-Y plot of any stress or force component for an element.

The following parameters are used in Static Analysis using Cyclic Symmetry:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMG.

STATIC ANALYSIS USING CYCLIC SYMMETRY

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.
4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPØDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices, rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
5. CTYPE - required - the BCD value of this parameter defines the type of cyclic symmetry as follows:
 - (1) RØT - rotational symmetry
 - (2) DRL - dihedral symmetry, using right and left halves
 - (3) DSA - dihedral symmetry, using symmetric and antisymmetric components
6. NSEGS - required - the integer value of this parameter is the number of identical segments in the structural model.
7. NLØAD - optional - the integer value of this parameter is the number of static loading conditions. The default value is 1.
8. CYCIØ - optional - the integer value of this parameter specifies the form of the input and output data. A value of +1 is used to specify physical segment representation, and a value of -1 for cyclic transform representation. The default value is +1.
9. CYCSEQ - optional - the integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.
10. KMAX - optional - the integer value of this parameter specifies the maximum value of the harmonic index. The default value is ALL which is $NSEGS/2$ for NSEGS even and $(NSEGS-1)/2$ for NSEGS odd.

NORMAL MODES ANALYSIS USING CYCLIC SYMMETRY

3.16 NORMAL MODES ANALYSIS USING CYCLIC SYMMETRY

3.16.1 DMAP Sequence for Normal Modes Analysis Using Cyclic Symmetry

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 15

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NU.15 NORMAL NODES ANALYSIS WITH CYCLIC SYMMETRY SERIES N $
2 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL/V,N,LUSET/ V,N,
              NOGPD,T $
3 SAVE       LUSET $
4 CHKPN T    GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL $
5 GP2        GEOM2,EQEXIN/ECT $
6 CHKPN T    ECT $
7 PARAM L    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
8 PURGE      PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
9 COND       P1,NOPCDB $
10 PLTSET     PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N,
              JUMPLOT=-1 $
11 SAVE      NSIL,JUMPLOT $
12 PRTMSG     PLTSETX// $
13 PARAM      //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
14 PARAM      //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
15 COND       P1,JUMPLOT $
16 PLOT        PLTPAR,GPSETS,ELSETS,CASECC,BGPD,T,EQEXIN,SIL,,,/PLOTX1/ V,N,
              NSIL/V,N,LUSET/V,N,JUMPLOT/V,N,PLTFLG/V,N,PFILE $
17 SAVE      JUMPLOT,PLTFLG,PFILE $
18 PRTMSG     PLTUX1// $
19 LABEL      P1 $
20 CHKPN T    PLTPAR,GPSETS,ELSETS $
21 GP3        GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $
22 CHKPN T    GPTT $
23 TA1        ECT,EPT,BGPD,T,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
24 SAVE      NOGENL,NOSIMP,GENEL $
25 COND       ERROR6,NOSIMP $

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RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 15

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

26	PURGE	OGPST/GENEL \$
27	CHKPNT	EST,GPECT,GEI,OGPST \$
28	PARAM	//C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 \$
29	PARAM	//C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 \$
30	EMG	EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V, N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPRDOD/ C,Y, CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y, CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC \$
31	SAVE	NOKGGX,NOMGG \$
32	CHKPNT	KELM,KDICT,MELM,MDICT \$
33	COND	JMPKGG,NOKGGX \$
34	EMA	GPECT,KDICT,KELM/KGGX,GPST \$
35	CHKPNT	KGGX,GPST \$
36	LABEL	JMPKGG \$
37	COND	ERROR1,NOMGG \$
38	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
39	CHKPNT	MGG \$
40	COND	LGPWG,GRDPNT \$
41	GPWG	BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS \$
42	DFP	OGPWG,,,,// \$
43	LABEL	LGPWG \$
44	EQUIV	KGGX,KGG/NOGENL \$
45	CHKPNT	KGG \$
46	COND	LBL11,NOGENL \$
47	SMA3	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP \$
48	CHKPNT	KGG \$
49	LABEL	LBL11 \$
50	PARAM	//C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 \$
51	GP4	CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/ V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N, NSKIP/V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$

NORMAL MODES ANALYSIS USING CYCLIC SYMMETRY

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 15

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

52	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA \$
53	COND	ERROR3,NOL \$
54	PARAM	//C,N,NOT/V,N,REACDATA/V,N,REACT \$
55	COND	ERROR4,REACDATA \$
56	PURGE	GM/MPCF1/GO/OMIT/KFS,QG/SINGLE \$
57	CHKPNT	GM,RG,GU,KFS,QG,uset,ASET \$
58	<u>GPCYC</u>	GEOM4,EQEXIN,uset/CYCD/V,Y,CTYPE/V,N,NOGO \$
59	SAVE	NOGO \$
60	CHKPNT	CYCD \$
61	COND	ERROR5,NOGO \$
62	COND	LBL4,GENEL \$
63	<u>GPSP</u>	GPL,GPST,uset,SIL/UGPST/V,N,NOGPST \$
64	SAVE	NOGPST \$
65	COND	LBL4,NOGPST \$
66	OFF	UGPST,,,,,// \$
67	LABEL	LBL4 \$
68	EQUIV	KGG,KNN/MPCF1/MGG,MNN/MPCF1 \$
69	CHKPNT	KNN,MNN \$
70	COND	LBL2,MPCF2 \$
71	<u>MCE1</u>	uset,RG/GM \$
72	CHKPNT	GM \$
73	<u>MCE2</u>	uset,GM,KGG,MGG,,/KNN,MNN,, \$
74	CHKPNT	KNN,MNN \$
75	LABEL	LBL2 \$
76	EQUIV	KNN,KFF/SINGLE/MNN,MFF/SINGLE \$
77	CHKPNT	KFF,MFF \$
78	COND	LBL3,SINGLE \$
79	<u>SCE1</u>	uset,KNN,MNN,,/KFF,KFS,,MFF,, \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 15

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

```

80  CHKPNT    KFS,KFF,MFF $
81  LABEL     LBL3 $
82  EQUIV     KFF,KAA/OMIT $
83  EQUIV     MFF,MAA/OMIT $
84  CHKPNT    KAA,MAA $
85  COND      LBL5,OMIT $
86  (SMP1)    USET,KFF,,,/GO,KAA,KUD,LOD,,,,, $
87  CHKPNT    GO,KAA $
88  (SMP2)    USET,GO,MFF/MAA $
89  CHKPNT    MAA $
90  LABEL     LBL5 $
91  (DPD)     DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,EED,EQDYN/V,N,
              LUSET/V,N,LUSETD/V,N,NUTFL/V,N,NODLT/V,N,NUPSDL/V,N,NQFRL/ V,
              N,NONLFT/V,N,NUTRL/V,N,NOEED/C,N,/V,N,NOUE $
92  SAVE      NOEED $
93  COND      ERROR2,NOEED $
94  CHKPNT    EED $
95  (CYCT2)   CYCD,XAA,MAA,,,/KKK,MKK,,,/C,N,FORE/V,Y,NSEGS=-1/V,Y,KINDEX=-1/
              V,Y,CYCSEQ=-1/C,N,1/V,N,NOGO $
96  SAVE      NOGO $
97  CHKPNT    KKK,MKK $
98  COND      ERROR5,NOGO $
99  (READ)    KKK,MKK,,,EED,,CASECC/LAMK,PHIK,MI,OEIGS/C,N,MODES/V,N,NEIGV $
100 SAVE      NEIGV $
101 CHKPNT    LAMK,PHIK,MI,OEIGS $
102 PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
103 OFP       LAMK,OEIGS,,,//V,N,CARDNO $
104 SAVE      CARDNO $
105 COND      FINIS,NEIGV $
106 (CYCT2)   CYCD,,,,PHIK,LAMK/,,,PHIA,LAMA/C,N,BACK/V,Y,NSEGS/V,Y,KINDEX/

```

NORMAL MODES ANALYSIS USING CYCLIC SYMMETRY

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 15

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

	V,Y,CYCSEQ/C,N,1/V,N,NUGO \$
107	SAVE NUGO \$
108	CHKPNT PHIA,LAMA \$
109	COND ERROR5,NUGO \$
110	<u>SDR1</u> USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,QG/C,N,1/C,N,REIG \$
111	CHKPNT PHIG,QG \$
112	PARAM //C,N,SUB/V,N,SCALAR/V,N,SIL/V,N,LUSET \$
113	EQUIV SIL,SIP/SCALAR/BGPDT,BGPDP/SCALAR \$
114	CHKPNT SIP,BGPDP \$
115	COND LBL7,SCALAR \$
116	<u>PLTTRAN</u> BGPDT,SIL/BGPDP,SIP/V,N,LUSET/V,N,LUSEP \$
117	SAVE LUSEP \$
118	CHKPNT BGPDP,SIP \$
119	LABEL LBL7 \$
120	<u>SDR2</u> CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDP,LAMA,QG,PHIG,EST,,/, OQG1,OPHIG,OES1,DEF1,PPHIG/C,N,REIG \$
121	OFF OPHIG,OQG1,DEF1,OES1,,,//V,N,CARDNU \$
122	SAVE CARDNO \$
123	COND P2,JUMPPLOT \$
124	<u>PLOT</u> PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIP,,,PPHIG,GPECT,OES1/ PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
125	SAVE PFILE \$
126	PRTMSG PLOTX2// \$
127	LABEL P2 \$
128	JUMP FINIS \$
129	LABEL ERROR1 \$
130	PRTPARM //C,N,-1/C,N,CYCMODES \$
131	LABEL ERROR2 \$
132	PRTPARM //C,N,-2/C,N,CYCMODES \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 15

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

133 LABEL ERROR3 \$
134 PRTPARM //C,N,-3/C,N,CYCMODES \$
135 LABEL ERROR4 \$
136 PRTPARM //C,N,-4/C,N,CYCMODES \$
137 LABEL ERROR5 \$
138 PRTPARM //C,N,-5/C,N,CYCMODES \$
139 LABEL ERROR6 \$
140 PRTPARM //C,N,-6/C,N,CYCMODES \$
141 LABEL FINIS \$
142 END \$

NORMAL MODES USING CYCLIC SYMMETRY

3.16.2 Description of DMAP Operations for Normal Modes Analysis Using Cyclic Symmetry

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
5. GP2 generates Element Connection Table with internal indices.
9. Go to DMAP No. 19 if no plot package is present.
10. PLTSET transforms user input into a form used to drive structure plotter.
12. PRTMSG prints error messages associated with structure plotter.
15. Go to DMAP No. 19 if no undeformed structure plot request.
16. PLØT generates all requested undeformed structure plots.
18. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
21. GP3 generates Static Loads Table and Grid Point Temperature Table.
23. TAI generates element tables for use in matrix assembly and stress recovery.
25. Go to DMAP No. 139 and print error message if no elements have been defined.
30. EMG generates structural element matrix tables and dictionaries for later assembly.
33. Go to DMAP No. 36 if no stiffness matrix is to be assembled.
34. EMA assembles stiffness matrix $[K_{gg}^X]$ and Grid Point Singularity Table.
37. Go to DMAP No. 129 and print error message if no mass matrix exists.
38. EMA assembles mass matrix $[M_{gg}]$.
40. Go to DMAP No. 43 if no weight and balance request.
41. GPWG generates weight and balance information.
42. ØFP formats weight and balance information and places it on the system output file for printing.
44. Equivalence $[K_{gg}^X]$ to $[K_{gg}]$ if no general elements.
46. Go to DMAP No. 49 if no general elements.
47. SMA3 adds general elements to $[K_{gg}^X]$ to obtain stiffness matrix $[K_{gg}]$.
51. GP4 generates flags defining members of various displacement sets (USET), forms multi-point constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.
53. Go to DMAP No. 133 and print error message if no independent degrees of freedom are defined.
55. Go to DMAP No. 135 and print error message if free-body supports are present.
58. GPCYC prepares segment boundary table.
61. Go to DMAP No. 137 and print error message if CYJØIN data is inconsistent.
62. Go to DMAP No. 67 if general elements present.

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63. GPSP determines if possible grid point singularities remain.
65. Go to DMAP No. 67 if no grid point singularities remain.
66. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.
68. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.
70. Go to DMAP No. 75 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
- 71.. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.
73. MCE2 partitions stiffness matrix

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & | & K_{nm} \\ \hline - & - & - \\ K_{mn} & | & K_{mm} \end{bmatrix}$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m]$$

76. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.
78. Go to DMAP No. 81 if no single-point constraints.
79. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & | & K_{fs} \\ \hline - & - & - \\ K_{sf} & | & K_{ss} \end{bmatrix} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & | & M_{fs} \\ \hline - & - & - \\ M_{sf} & | & M_{ss} \end{bmatrix}$$

82. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.
83. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.
85. Go to DMAP No. 90 if no omitted coordinates.
86. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & | & K_{ao} \\ \hline - & - & - \\ K_{oa} & | & K_{oo} \end{bmatrix}$$

NORMAL MODES USING CYCLIC SYMMETRY

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

88. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & | & M_{ao} \\ \hline M_{oa} & | & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$$

91. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

93. Go to DMAP No. 131 and print error message if no Eigenvalue Extraction Data.

95. CYCT2 transforms matrices from symmetric components to solution set.

98. Go to DMAP No. 137 and print error message if CYCT2 error was found.

99. READ extracts real eigenvalues from the equation

$$[K_{kk} - \lambda M_{kk}]\{u_k\} = 0$$

calculates modal mass matrix

$$[m] = [\phi_k^T][M_{kk}][\phi_k]$$

and normalizes eigenvectors according to one of the following user requests:

- 1) Unit value of selected coordinate
- 2) Unit value of largest component
- 3) Unit value of generalized mass.

103. ØFP formats eigenvalues and summary of eigenvalue extraction information and places them on the system output file for printing.

105. Go to DMAP No. 141 and exit if no eigenvalues found.

106. CYCT2 finds symmetric components of eigenvectors from solution set eigenvectors.

109. Go to DMAP No. 137 and print error message if CYCT2 error was found.

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110. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \quad \begin{pmatrix} \phi_a \\ - \\ \phi_o \end{pmatrix} = \{\phi_f\} \quad ,$$

$$\begin{pmatrix} \phi_f \\ - \\ \phi_s \end{pmatrix} = \{\phi_n\} \quad , \quad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\begin{pmatrix} \phi_n \\ - \\ \phi_m \end{pmatrix} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}]^T \{\phi_f\}$.

- 113. Equivalence SIL to SIP and BGPDT to BGPDP when one or more geometric grid points exist.
- 116. PLTRAN modifies BGPDT and SIL for functional modules SDR2 and PLDT.
- 120. SDR2 calculates element forces and stresses (DEF1, DES1) and prepares eigenvectors and single-point forces of constraint for output (DPHIG, PPHIG, DQGI).
- 121. DFP formats tables prepared by SDR2 and places them on the system output file for printing.
- 123. Go to DMAP No. 127 if no deformed structure plots are requested.
- 124. PLDT generates all requested deformed structure plots.
- 126. PRTMSG prints plotter data and engineering data for each deformed plot generated.
- 128. Go to DMAP No. 141 and make normal exit.
- 130. NORMAL MODES WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 1 - MASS MATRIX REQUIRED FOR REAL EIGENVALUE ANALYSIS.
- 132. NORMAL MODES WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.
- 134. NORMAL MODES WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 3 - NO INDEPENDENT DEGREES OF FREEDOM HAVE BEEN DEFINED.
- 136. NORMAL MODES WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 4 - FREE BODY SUPPORTS NOT ALLOWED.
- 138. NORMAL MODES WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 5 - CYCLIC SYMMETRY DATA ERROR.
- 140. NORMAL MODES WITH CYCLIC SYMMETRY ERROR MESSAGE NO. 6 - NO STRUCTURAL ELEMENTS DEFINED.

NORMAL MODES USING CYCLIC SYMMETRY

3.16.3 Automatic Output for Normal Mode Analysis Using Cyclic Symmetry

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
 - (1) Two consecutive singularities encountered while performing triangular decomposition.
 - (2) Four shift points while tracking a single root.
 - (3) All eigenvalues found in the frequency range specified.
 - (4) Three times the number of roots estimated in the frequency range have been extracted.
 - (5) All eigenvalues that exist in the problem have been found.
 - (6) The number of roots desired have been found.
 - (7) One or more eigenvalues have been found outside the frequency range specified.
 - (8) Insufficient time to find another root.
 - (9) Unable to converge.
7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

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1. Number of eigenvalues extracted.
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Reason for termination.
 - (1) The number of roots desired have been found.
 - (2) All predictions for eigenvalues are outside the frequency range specified.
 - (3) Insufficient time to find another root.
 - (4) Matrix is singular at first three starting points.
8. Largest off-diagonal modal mass term and the number failing the criterion.
9. Swept determinant function for each starting point.

The following summary of the eigenvalue analysis performed using the Givens method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of eigenvectors computed.
3. Number of eigenvalue convergence failures.
4. Number of eigenvector convergence failures.
5. Reason for termination.
 - (1) Normal termination.
 - (2) Insufficient time to calculate eigenvalues and number of eigenvectors requested.
 - (3) Insufficient time to find additional eigenvectors.
6. Largest off-diagonal modal mass term and the number failing the criterion.

3.16.4 Case Control Deck and Parameters for Normal Modes Analysis Using Cyclic Symmetry

The following items relate to subcase definition and data selection for Normal Modes:

1. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.
2. An SPC set must be selected unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.

NORMAL MODES USING CYCLIC SYMMETRY

3. Multiple subcases are used only to control output requests. A single subcase is sufficient if the same output is desired for all modes. If multiple subcases are present, the output requests will be honored in succession for increasing mode numbers. M0DES may be used to repeat subcases in order to make the same output request for several consecutive modes.

Each NASTRAN run calculates modes for only one symmetry index, k. The following output may be requested for Normal Mode Analysis with Cyclic Symmetry:

1. Eigenvectors along with the associated eigenvalue for each mode.
2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.
3. Forces and stresses in selected elements for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected modes.

The following parameters are used in Normal Mode Analysis using Cyclic Symmetry:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.
3. C0UPMASS - CPBAR, CPR0D, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
4. CTYPE - required - the BCD value of this parameter defines the type of cyclic symmetry as follows:
 - (1) R0T - rotational symmetry
 - (2) DRL - dihedral symmetry, using right and left halves
 - (3) DSA - dihedral symmetry, using symmetric and antisymmetric components

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5. NSEGS - required - the integer value of this parameter is the number of identical segments in the structural model.
6. CYCSEQ - optional - the integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.
7. KINDEX - required in normal modes with cyclic symmetry (Rigid Format 15). The integer value of this parameter specifies a single value of the harmonic index.

STATIC HEAT TRANSFER ANALYSIS

3.17 STATIC HEAT TRANSFER ANALYSIS

3.17.1 DMAP Sequence for Static Heat Transfer Analysis

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 01 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
 DMAP-DMAP INSTRUCTION
 NO.

```

1 BEGIN      NU.1 STATIC HEAT TRANSFER ANALYSIS - SERIES N $
2 FILE       HLLL=TAPE $
3 FILE       HQG=APPEND/HPGG=APPEND/HUGV=APPEND/HGM=SAVE/HKNN=SAVE $
4 GP1        GEOM1,GEOM2,/GPL,HEQEXIN,GPD,T,CSTM,BGPD,T,HSIL/V,N,HLUSET/  V,
              N,NUGPD,T $
5 SAVE       HLUSET $
6 CHKPNT     GPL,HEQEXIN,GPD,T,CSTM,BGPD,T,HSIL $
7 GP2        GEOM2,HEQEXIN/ECT $
8 CHKPNT     ECT $
9 PARAML     PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
10 PURGE      PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
11 COND       HP1,NOPCDB $
12 PLTSET     PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,HNSIL/ V,N,
              JUMPLOT=-1 $
13 SAVE       HNSIL,JUMPLOT $
14 PRTMSG     PLTSETX// $
15 PARAM      //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
16 PARAM      //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
17 COND       HP1,JUMPLOT $
18 PLOT       PLTPAR,GPSETS,ELSETS,CASECC,BGPD,T,HEQEXIN,HSIL,,,/PLOTX1/ V,N,
              HNSIL/V,N,HLUSET/V,N,JUMPLOT/V,N,PLTFLG/V,N,PFILE $
19 SAVE       JUMPLOT,PLTFLG,PFILE $
20 PRTMSG     PLUTX1// $
21 LABEL      HP1 $
22 CHKPNT     PLTPAR,GPSETS,ELSETS $
23 GP3        GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/V,N,NOGRAV $
24 CHKPNT     HSLT,GPTT $
25 TA1        ECT,EPT,BGPD,T,HSIL,GPTT,CSTM/HEST,,HGPECT,/V,N,HLUSET/  V,N,
              NUSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
  
```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 01 HEAT

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NU.

26	SAVE	NOSIMP \$
27	COND	ERROR4,NOSIMP \$
28	PURGE	GPST/NOSIMP \$
29	CHKPNT	HEST,HGPECT,GPST \$
30	COND	HLBL1,NOSIMP \$
31	PARAM	//C,N,ADD/V,N,HNOKGG/C,N,1/C,N,0 \$
32	EMG	HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKOICT,,,,/V,N,HNOKGG \$
33	SAVE	HNOKGG \$
34	CHKPNT	HKELM,HKOICT \$
35	COND	HLBL1,HNOKGG \$
36	EMA	HGPECT,HKOICT,HKELM/HKGG,GPST \$
37	CHKPNT	HKGG,GPST \$
38	LABEL	HLBL1 \$
39	PARAM	//C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 \$
40	JUMP	HLBL11 \$
41	LABEL	HLBL11 \$
42	GP4	CASECC,GEOM4,HEQEXIN,HSIL,GPD,T,BGPD,T,CSTM/RG,YS,HUSET,HASET/V, N,HLUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/ V,N,NSKIP/V,N,HREPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
43	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,HREPEAT,NOSET,NOL,NOA \$
44	COND	ERROR3,NOL \$
45	PARAM	//C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT \$
46	PURGE	HKRR,HKLR,HQR,HDM/REACT/GM/MPCF1/HGO,HKOO,HLOO,HPO,HUOOV, HRUOV/OMIT/HPS,HKFS,HKSS/SINGLE/HQG/NOSR \$
47	CHKPNT	HKRR,HKLR,HQR,HDM,G,HGO,HKOO,HLOO,HPO,HUOOV,HRUOV,HPS,HKFS, HKSS,HQG,HUSET,RG,YS,HASET \$
48	GPSP	GPL,GPST,HUSET,HSIL/UGPST/V,N,NOGPST \$
49	SAVE	NOGPST \$
50	COND	HLBL4,NOGPST \$
51	OFF	OGPST,,,,// \$

Top of DMAP Loop

STATIC HEAT TRANSFER ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 01 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

52	LABEL	HLBL4 \$
53	EQUIV	HKGG,HKNN/MPCF1 \$
54	CHKPNT	HKNN \$
55	COND	HLBL2,MPCF2 \$
56	MCE1	HUSET,RG/GM \$
57	CHKPNT	GM \$
58	MCE2	HUSET,GM,HKGG,,,/HKNN,,, \$
59	CHKPNT	HKNN \$
60	LABEL	HLBL2 \$
61	EQUIV	HKNN,HKFF/SINGLE \$
62	CHKPNT	HKFF \$
63	COND	HLBL3,SINGLE \$
64	SCE1	HUSET,HKNN,,,/HKFF,HKFS,HKSS,,, \$
65	CHKPNT	HKFS,HKSS,HKFF \$
66	LABEL	HLBL3 \$
67	EQUIV	HKFF,HKAA/OMIT \$
68	CHKPNT	HKAA \$
69	COND	HLBL5,OMIT \$
70	SMP1	HUSET,HKFF,,,/HGO,HKAA,HKOO,HLOO,,,,, \$
71	CHKPNT	HGO,HKAA,HKOO,HLOO \$
72	LABEL	HLBL5 \$
73	EQUIV	HKAA,HKLL/REACT \$
74	CHKPNT	HKLL \$
75	COND	HLBL6,REACT \$
76	RBMG1	HUSET,HKAA,/HKLL,HKLR,HKRR,,, \$
77	CHKPNT	HKLL,HKLR,HKRR \$
78	LABEL	HLBL6 \$
79	RBMG2	HKLL/HLLL \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 01 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

80	CHKPNT	HLLL \$
81	COND	HLBL7, REACT \$
82	RBM63	HLLL, HKLR, HKRR/HDM \$
83	CHKPNT	HDM \$
84	LABEL	HLBL7 \$
85	SSG1	HSLT, BGPDT, CSTM, HSIL, HEST, MPT, GPTT, EDT, , CASECC, DIT/HPG/V, N, HLUSET/V, N, NSKIP \$
86	CHKPNT	HPG \$
87	EQUIV	HPG, HPL/NUSET \$
88	CHKPNT	HPL \$
89	COND	HLBL10, NOSET \$
90	SSG2	HUSET, GM, YS, HKFS, HGU, HDM, HPG/HQR, HPO, HPS, HPL \$
91	CHKPNT	HQR, HPO, HPS, HPL \$
92	LABEL	HLBL10 \$
93	SSG3	HLLL, HKLL, HPL, HLOO, HKOO, HPO/HULV, HUOOV, HRULV, HRUOV/V, N, OMIT/ V, Y, IRES=-1/V, N, NSKIP/V, N, EPSI \$
94	SAVE	EPSI \$
95	CHKPNT	HULV, HUOOV, HRULV, HRUOV \$
96	COND	HLBL9, IRES \$
97	MATGPR	GPL, HUSET, HSIL, HRULV//C, N, L \$
98	MATGPR	GPL, HUSET, HSIL, HRUOV//C, N, U \$
99	LABEL	HLBL9 \$
100	SDR1	HUSET, HPG, HULV, HUOOV, YS, HGO, GM, HPS, HKFS, HKSS, HQR/HUGV, HPGG, HQG/ V, N, NSKIP/C, N, HSTATICS \$
101	CHKPNT	HUGV, HPGG, HQG \$
102	COND	HLBL8, HREPEAT \$
103	REPT	HLBL11, 100 \$
104	JUMP	ERROR1 \$
105	PARAM	//C, N, NOT/V, N, HTEST/V, N, HREPEAT \$
106	COND	ERROR5, HTEST \$

Bottom of DMAP Loop

STATIC HEAT TRANSFER ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 01 HEAT

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

107	LABEL	HLBL8 \$
108	CHKPNT	CSTM \$
109	<u>SDR2</u>	CASECC,CSTM,MPT,DIT,HEQEXIN,HSIL,GPTT,EDT,BGPD, ,HQQ,HUGV, HEST,,HPGG/HOPG1,HQGG1,HUUGV1,HUES1,HQEF1,HPUGV1/C,N,STATICS \$
110	PARAM	//C,N,MPY/V,N,CARDNO/C,N,O/C,N,O \$
111	OFF	HUUGV1,HOPG1,HQGG1,HQEF1,HUES1,//V,N,CARDNO \$
112	SAVE	CARDNO \$
113	COND	HP2,JUMPPLOT \$
114	<u>PLOT</u>	PLTPAR,GPSETS,ELSETS,CASECC,BGPD,HEQEXIN,HSIL,HPUGV1,,HGPECT, HUES1/PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N, PFILE \$
115	SAVE	PFILE \$
116	PRTMSG	PLOTX2// \$
117	LABEL	HP2 \$
118	JUMP	FINIS \$
119	LABEL	ERROR1 \$
120	PRTPARM	//C,N,-1/C,N,HSTA \$
121	LABEL	ERROR3 \$
122	PRTPARM	//C,N,-3/C,N,HSTA \$
123	LABEL	ERROR4 \$
124	PRTPARM	//C,N,-4/C,N,HSTA \$
125	LABEL	ERROR5 \$
126	PRTPARM	//C,N,-5/C,N,HSTA \$
127	LABEL	FINIS \$
128	END	\$

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3.17.2 Description of DMAP Operations for Static Heat Transfer Analysis

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
7. GP2 generates Element Connection Table with internal indices.
11. Go to DMAP No. 21 if no plot package is present.
12. PLTSET transforms user input into a form used to drive structure plotter.
14. PRTMSG prints error messages associated with structure plotter.
17. Go to DMAP No. 21 if no undeformed structure plot request.
18. PLØT generates all requested undeformed structure plots.
20. PRTMSG prints plotter data and engineering data for each undeformed plot generated.
23. GP3 generates Static Loads Table and Grid Point Temperature Table.
25. TAI generates element tables for use in matrix assembly and stress recovery.
27. Go to DMAP No. 123 and print error message if no elements have been defined.
30. Go to DMAP No. 38 if there are no structural elements.
32. EMG generates structural element matrix tables and dictionaries for later assembly.
35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.
36. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
40. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.
41. Beginning of loop for additional constraint sets.
42. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{u_s\}$.
44. Go to DMAP No. 121 and print error message if no independent degrees of freedom are defined.
48. GPSP determines if possible grid point singularities remain.
50. Go to DMAP No. 52 if no grid point singularities remain.
51. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.
53. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.
55. Go to DMAP No. 60 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
56. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

STATIC HEAT TRANSFER

58. MCE2 partitions stiffness matrix

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & K_{nm} \\ - & - \\ K_{mn} & K_{mm} \end{bmatrix}$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

61. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

63. Go to DMAP No. 66 if no single-point constraints.

64. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & K_{fs} \\ - & - \\ K_{sf} & K_{ss} \end{bmatrix}$$

67. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

69. Go to DMAP No. 82 if no omitted coordinates.

70. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & K_{ao} \\ - & - \\ K_{oa} & K_{oo} \end{bmatrix},$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

73. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

75. Go to DMAP No. 78 if no free-body supports.

76. RBMG1 partitions out free-body supports

$$[K_{aa}] = \begin{bmatrix} K_{\ell\ell} & K_{\ell r} \\ - & - \\ K_{r\ell} & K_{rr} \end{bmatrix}$$

79. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

RIGID FORMATS

81. Go to DMAP No. 84 if no free-body supports.

82. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||} .$$

85. SSG1 generates static load vectors $\{P_g\}$.

87. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

90. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{p}_n \\ \bar{p}_m \end{Bmatrix} , \quad \{P_n\} = \{\bar{p}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \begin{Bmatrix} \bar{p}_f \\ \bar{p}_s \end{Bmatrix} , \quad \{P_f\} = \{\bar{p}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \begin{Bmatrix} \bar{p}_a \\ \bar{p}_o \end{Bmatrix} , \quad \{P_a\} = \{\bar{p}_a\} + [G_o^T]\{P_o\} ,$$

$$\{P_a\} = \begin{Bmatrix} \bar{p}_\ell \\ \bar{p}_r \end{Bmatrix}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

93. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^0\} = [K_{oo}]^{-1}\{P_o\} ,$$

STATIC HEAT TRANSFER

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} ,$$

$$\epsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUOV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^0\} ,$$

$$\epsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^0\}}$$

96. Go to DMAP No. 99 if residual vectors are not to be printed.
97. MATGPR prints the residual vector for independent coordinates (RULV).
98. MATGPR prints the residual vector for omitted coordinates (RUOV).
100. SDR1 recovers dependent displacements

$$\begin{Bmatrix} u_\ell \\ u_r \end{Bmatrix} = \{u_a\} ,$$

$$\{u_o\} = [G_o]\{u_a\} + \{u_o^0\} ,$$

$$\begin{Bmatrix} u_a \\ u_o \end{Bmatrix} = \{u_f\} ,$$

$$\begin{Bmatrix} u_f \\ Y_s \end{Bmatrix} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\} ,$$

$$\begin{Bmatrix} u_n \\ u_m \end{Bmatrix} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} .$$

102. Go to DMAP No. 107 if all constraint sets have been processed.
103. Go to DMAP No. 41 if additional sets of constraints need to be processed.
104. Go to DMAP No. 119 and print error message if number of loops exceeds 100.
106. Go to DMAP No. 125 and print error message if multiple boundary conditions are attempted with improper subset.

RIGID FORMATS

109. SDR2 calculates element forces and stresses ($\sigma_{EF1}, \sigma_{ES1}$) and prepares load vectors, displacement vectors and single-point forces of constraint for output ($\sigma_{PG1}, \sigma_{UGV1}, \sigma_{UGV1}, \sigma_{QG1}$).
111. σ_{FP} formats tables prepared by SDR2 and places them on the system output file for printing.
113. Go to DMAP No. 117 if no deformed structure plots are requested.
114. σ_{LOT} generates all requested deformed structure plots.
116. σ_{RTMSG} prints plotter data and engineering data for each deformed plot generated.
118. Go to DMAP No. 127 and make normal exit.
120. STATIC HEAT TRANSFER ANALYSIS ERROR MESSAGE NO. 1 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.
122. STATIC HEAT TRANSFER ANALYSIS ERROR MESSAGE NO. 3 - NO INDEPENDENT DEGREES OF FREEDOM HAVE BEEN DEFINED.
124. STATIC HEAT TRANSFER ANALYSIS ERROR MESSAGE NO. 4 - NO ELEMENTS HAVE BEEN DEFINED.
126. STATIC HEAT TRANSFER ANALYSIS ERROR MESSAGE NO. 5 - A LOOPING PROBLEM RUN ON NON-LOOPING SUBSET.

STATIC HEAT TRANSFER

3.17.3 Case Control Deck and Parameters for Static Heat Transfer Analysis

The following items relate to subcase definition and data selection for Static Heat Transfer Analysis:

1. A separate subcase must be defined for each unique combination of constraints and static loads.
2. A static loading condition must be defined for (not necessarily within) each subcase with a `LØAD` selection, unless all loading is specified with grid point temperatures on `SPC` cards.
3. An `SPC` set must be selected for (not necessarily within) each subcase, unless all constraints are specified on `GRID` cards or `Scalar Connection` cards.
4. Loading conditions associated with the same sets of constraints should be in contiguous subcases, in order to avoid unnecessary looping.
5. `REPCASE` may be used to repeat subcases in order to allow multiple sets of the same output item.

The following output may be requested for Static Heat Transfer Analysis solutions:

1. Temperatures (`THERMAL`) and nonzero components of static loads (`ØLØAD`) and constrained heat flow (`SPCFØRCE`) at selected grid points or scalar points.
2. The punch option of a `THERMAL` request will produce `TEMP` bulk data cards.
3. Flux density (`ELFØRCE`) in selected elements.
4. Undeformed plots of the structural model and temperature profiles.

The following parameters are used in Static Heat Transfer Analysis:

1. `IRES` - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of `SSG3`.

NONLINEAR STATIC HEAT TRANSFER ANALYSIS

3.18 NONLINEAR STATIC HEAT TRANSFER ANALYSIS

3.18.1 DMAP Sequence for Nonlinear Static Heat Transfer Analysis

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 3 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      NO.03 NONLINEAR STATIC HEAT TRANSFER ANALYSIS - SERIES N $
2 GP1        GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/  V,
              N,NOGPDT $
3 SAVE       HLUSET $
4 CHKPNT     GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL $
5 GP2        GEOM2,HEQEXIN/ECT $
6 CHKPNT     ECT $
7 PARAML     PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
8 PURGE      PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
9 COND       HP1,NOPCDB $
10 PLTSET     PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,HNSIL/ V,N,
              JUMPPLOT=-1 $
11 SAVE      HNSIL,JUMPPLOT $
12 PRTMSG     PLTSETX// $
13 PARAM      //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
14 PARAM      //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
15 COND       HP1,JUMPPLOT $
16 PLUT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,,/PLOTX1/ V,N,
              HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
17 SAVE      JUMPPLOT,PLTFLG,PFILE $
18 PRTMSG     PLOTX1// $
19 LABEL      HP1 $
20 CHKPNT     PLTPAR,GPSETS,ELSETS $
21 GP3        GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/V,N,NOGRAV $
22 CHKPNT     HSLT,GPTT $
23 TAL        ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,/V,N,HLUSET/  V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,HXYZ $
24 SAVE      NOSIMP $
25 COND       ERROR2,NOSIMP $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 3 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

26	CHKPNT	HEST,HGPECT \$
27	PARAM	//C,N,ADD/V,N,HNOKGG/C,N,1/C,N,0 \$
28	EMG	HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,,/V,N,HNOKGG \$
29	SAVE	HNOKGG \$
30	CHKPNT	HKELM,HKDICT \$
31	COND	JMPKGGX,HNOKGG \$
32	EMA	HGPECT,HKDICT,HKELM/HKGGX,GPST \$
33	CHKPNT	HKGGX,GPST \$
34	LABEL	JMPKGGX \$
35	RMG	HEST,MATPOOL,GPTT,HKGGX/HRGG,HQGE,HKGG/C,Y,TABS/C,Y,SIGMA=0.0/ V,N,HNLR/V,N,HLUSET \$
36	SAVE	HNLR \$
37	EQUIV	HKGGX,HKGG/HNLR \$
38	PURGE	HQGE,HRGG/HNLR \$
39	CHKPNT	HKGG,HQGE,HRGG \$
40	GP4	CASECC,GEOM4,HEQEXIN,HSIL,GPDT,BGPDT,CSTM/RG,YS,HUSET,HASET/V, N,HLUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/ V,N,NSKIP/V,N,HREPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
41	SAVE	MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,HREPEAT,NOSET,NOL,NOA \$
42	COND	ERROR1,NOL \$
43	PURGE	GM/MPCF1/HPS,HKFS,HKSS,HKSF,HRSN,HQG/SINGLE \$
44	CHKPNT	GM,HPS,HKFS,HKSS,HUSET,RG,HKSF,HRSN,YS \$
45	GPSP	GPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST \$
46	SAVE	NOGPST \$
47	COND	HLBL5,NOGPST \$
48	DFP	OGPST,,,,,// \$
49	LABEL	HLBL5 \$
50	EQUIV	HKGG,HKNN/MPCF1/HRGG,HRNN/MPCF1 \$
51	CHKPNT	HKNN,HRNN \$
52	COND	HLBL1,MPCF2 \$

NONLINEAR STATIC HEAT TRANSFER ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 3 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

53 MCE1 HUSET, RG/GM \$
54 CHKPNT GM \$
55 MCE2 HUSET, GM, HKGG, HRGG, , /HKNN, HRNN, , \$
56 CHKPNT HKNN, HRNN \$
57 LABEL HLBL1 \$
58 EQUIV HKNN, HKFF/SINGLE/HRNN, HRFN/SINGLE \$
59 CHKPNT HKFF, HRFN \$
60 COND HLBL2, SINGLE \$
61 VEC HUSET/VFS/C, N, N/C, N, F/C, N, S \$
62 PARTN HKNN, VFS, /HKFF, HKSF, HKFS, HKSS \$
63 PARTN HRNN, , VFS/HRFN, HRSN, , /C, N, 1 \$
64 LABEL HLBL2 \$
65 CHKPNT HKFS, HKSS, HKFF, HKSF, HRFN, HRSN \$
66 DECOMP HKFF/HLLL, HULL/C, N, O/C, N, O/V, N, MDIAG/V, N, DET/V, N, PWR/V, N,
KSING \$
67 SAVE KSING \$
68 COND ERROR3, KSING \$
69 CHKPNT HLLL, HULL \$
70 SSG1 HSLT, BGPDT, CSTM, HSIL, HEST, MPT, GPTT, EDT, , CASECC, DIT/HPG/V, N,
HLUSET/V, N, NSKIP \$
71 CHKPNT HPG \$
72 EQUIV HPG, HPF/NOSET \$
73 COND HLBL3, NOSET \$
74 SSG2 HUSET, GM, , HKFS, , , HPG/ , , HPS, HPF \$
75 LABEL HLBL3 \$
76 CHKPNT HPF, HPS \$
77 SSGHT HUSET, HSIL, GPTT, GM, HEST, MPT, DIT, HPF, HPS, HKFF, HKFS, HKSF, HKSS,
HRFN, HRSN, HLLL, HULL/HUGV, HQG, HRULV/V, N, HNNLK=1/V, N, HNLR/ C, Y,
EPSHT=.001/C, Y, TABS=0.0/C, Y, MAXIT=4/V, Y, IRES/V, N, MPCF1/V, N,
SINGLE \$
78 CHKPNT HUGV, HQG, HRULV \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 3 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

79	COND	HLBL4, IRES \$
80	MATGPR	GPL, HUSET, HSIL, HRULV//C, N, F \$
81	LABEL	HLBL4 \$
82	PLITRAN	BGPDT, HSIL/BGPDP, HSIP/V, N, HLUSET/V, N, HLUSEP \$
83	SAVE	HLUSEP \$
84	CHKPNT	BGPDP, HSIP \$
85	SDR2	CASECC, CSTM, MPT, DIT, HEQEXIN, HSIL, GPTT, EDT, BGPDP, , HQG, HUGV, HEST, , HPG/HOPG1, HOQG1, HOUGV1, HOES1, HOEF1, HPUGV1/C, N, STATICS \$
86	PARAM	//C, N, MPY/V, N, CARDNO/C, N, O/C, N, O \$
87	OFF	HOUGV1, HJPG1, HOQG1, , , //V, N, CARDNO \$
88	SAVE	CARDNO \$
89	SDRHT	HSIL, HUSET, HUGV, HOEF1, HSLT, HEST, DIT, HQGE, , /HCEF1X/C, Y, TABS/V, N, HNLR \$
90	OFF	HOEF1X, , , , , //V, N, CARDNO \$
91	SAVE	CARDNO \$
92	COND	HP2, JUMPLOT \$
93	PLOT	PLTPAR, GPSETS, ELSETS, CASECC, BGPDT, HEQEXIN, HSIP, HPUGV1, , HGPECT, HOES1/PLOTX2/V, N, NSIL/V, N, HLUSEP/V, N, JUMPLOT/ V, N, PLTF LG/V, N, PFILE \$
94	PRTMSG	PLOTX2// \$
95	LABEL	HP2 \$
96	JUMP	FINIS\$
97	LABEL	ERROR1 \$
98	PRTPARM	//C, N, -1/C, N, HNLI \$
99	LABEL	ERROR2 \$
100	PRTPARM	//C, N, -2/C, N, HNLI \$
101	LABEL	ERROR3 \$
102	PRTPARM	//C, N, -3/C, N, HNLI \$
103	LABEL	FINIS\$
104	END	\$

NONLINEAR STATIC HEAT TRANSFER ANALYSIS

3.18.2 Description of DMAP Operations for Nonlinear Static Heat Transfer Analysis

2. GP1 generates grid point location tables and tables relating internal and external degree of freedom numbers.
5. GP2 generates the Element Connection Table.
9. Go to DMAP No. 19 if no plot package is present.
10. PLTSET transforms the input data into plot data tables.
12. PRTMSG prints error messages associated with the plot data.
15. Go to DMAP No. 19 if no undeformed structure plot request.
16. PLØT generates all plots of the structure without temperature profiles.
18. PRTMSG prints plotter and engineering data for each generated plot.
21. GP3 generates applied heat flux load tables (SLT) and the grid point temperature table.
23. TAI generates element tables for use in matrix formulation, load generation, and element heat flux data recovery.
25. Go to DMAP No. 99 and print error message if no elements have been defined.
28. EMG generates structural element matrix tables and dictionaries for later assembly.
31. Go to DMAP No. 34 if no conductivity matrix is to be assembled.
32. EMA assembles conductivity matrix $[K_{gg}^X]$ and Grid Point Singularity Table.
35. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the conductivity matrix. ⁹⁹The element radiation flux matrix, $[Q_{ge}]$, is also generated for use in recovery data for the HBDY elements.
37. Equivalence $[K_{gg}^X]$ to $[K_{gg}]$ if no linear component of radiation.
40. GP4 generates flags defining member of various displacement sets (USET) and forms multi-point constraint equations $[R_g] \{u_g\} = \{0\}$.
42. Go to DMAP instruction 97 if no independent degrees of freedom are defined.
45. GPSP determines if possible matrix singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.
47. Go to DMAP No. 49 if no Grid Point Singularity Table.
48. ØFP prints the singularity messages.
50. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[R_{gg}]$ to $[R_{nn}]$ if no multi-point constraints exist.
52. Go to DMAP statement 57 if no multi-point constraints exist.
53. MCE1 partitions the multi-point constraint equation matrix $[R_g] = [R_m; R_n]$ and solves for the multi-point constraint transformation matrix

$$[G_m] = - [R_m]^{-1} [R_n].$$

RIGID FORMATS

55. MCE2 partitions conductivity and radiation matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right] \quad \text{and} \quad [R_{gg}] = \left[\begin{array}{c|c} \bar{R}_{nn} & R_{nm} \\ \hline R_{mn} & R_{mm} \end{array} \right],$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T] [K_{mn}] + [K_{mn}^T] [G_m] + [G_m^T] [K_{mm}] [G_m] \quad \text{and}$$

$$[R_{nn}] = [\bar{R}_{nn}] + [G_m^T] [R_{mn}] + [R_{mn}^T] [G_m] + [G_m^T] [R_{mm}] [G_m].$$

58. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[R_{nn}]$ to $[R_{fn}]$ if no single-point constraints exist.

60. Go to DMAP statement 64 if no single-point constraints exist.

61. VEC generates a partitioning vector $u_n \rightarrow u_f + u_s$.

62. PARTN partitions the conductivity matrix

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{fs} & K_{ss} \end{array} \right].$$

63. PARTN partitions the radiation matrix

$$[R_{nn}] = \left[\begin{array}{c} R_{fn} \\ \hline R_{sn} \end{array} \right].$$

66. DECØMP decomposes the potentially unsymmetric matrix K_{ff} into upper and lower triangular factors $[U_{\ell\ell}]$ and $[L_{\ell\ell}]$.

68. Go to DMAP statement 101 if the matrix is singular.

70. SSG1 generates the input heat flux vector $\{P_g\}$.

72. Equivalence $\{P_g\}$ to $\{P_f\}$ if no constraints applied.

73. Go to DMAP statement 75 if no constraints of any kind exist.

74. SSG2 reduces the heat flux vector

$$\{P_g\} = \left\{ \begin{array}{c} \bar{P}_n \\ \hline P_m \end{array} \right\},$$

$$\{P_n\} = \{\bar{P}_n\} + [G_m^T] \{P_m\},$$

NONLINEAR STATIC HEAT TRANSFER ANALYSIS

$$\{P_n\} = \begin{Bmatrix} P_f \\ \vdots \\ P_s \end{Bmatrix} .$$

77. SSGHT solves the nonlinear heat transfer problems by iteration. User input parameters EPSHT and MAXIT are used to limit the iterations. For details, refer to Section 8 of the NASTRAN Theoretical Manual. The output data blocks are: $\{u\}$, the solution temperature vector, $\{q\}$, the heat flux due to single point constraints, and $\{\delta P_\ell\}$, the matrix of residual heat fluxes at each iteration step.
79. Go to DMAP statement 81 if no residual vectors are desired.
80. MATGPR prints the matrix of residual vectors.
82. PLTTRAN transforms the grid point definition tables into a format for plotting temperature solutions.
85. SDR2 calculates the heat flux due to conductivity and convection in the elements and prepares the solution vectors for output.
87. ØFP formats tables prepared by SDR2 for output.
89. SDRHT processes the HBDY elements to produce heat flux into the elements due to convection, radiation, and user applied flux.
90. ØFP formats the output element flux table for output.
92. Go to DMAP 95 if no temperature profile plots are requested.
93. PLØT generates temperature profile plots.
94. PRTMSG prints plotter data and engineering data for each plot generated.
96. Go to DMAP No. 103 and make normal exit.
98. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.
100. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 2 - NØ SIMPLE STRUCTURAL ELEMENTS.
102. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 3 - STIFFNESS MATRIX SINGULAR.

3.18.3 Case Control Deck and Parameters for Nonlinear Static Heat Transfer Analysis

The following items relate to subcase definition and data selection for Nonlinear Static Heat Transfer Analysis:

1. A single subcase must be defined with a single loading condition (LOAD) and a single constraint condition (SPC).
2. An estimated temperature distribution vector must be defined on TEMP cards and selected with a TEMP(MATERIAL) request. Temperatures for constrained components are taken from these TEMP cards and entries on SPC cards are ignored.

The following output may be requested for the last iteration in Nonlinear Static Heat Transfer Analysis:

1. Temperature (THERMAL) and nonzero components of static loads (LOAD) and constrained heat flow (SPCFORCE) at selected grid points or scalar points.
2. The punch option of a THERMAL request will produce TEMP bulk data cards.
3. Flux density (ELFORCE) in selected elements. In the case of CHBDY elements, a flux density summary is produced that includes applied flux, radiation flux, and convective flux.
4. Undeformed plots of the structural model and temperature profiles.

The following parameters are used in Nonlinear Static Heat Transfer Analysis:

1. MAXIT - optional - the integer value of this parameter limits the maximum number of iterations.
2. EPSHT - optional - the real value of this parameter is used to test the convergence of the solution.
3. TABS - optional - the real value of this parameter is the absolute reference temperature.
4. SIGMA - optional - the real value of this parameter is the Stefan-Boltzmann constant.
5. IRES - optional - a positive value of this parameter will cause the printing of the residual vectors following the execution of SSGHT for each iteration.

TRANSIENT HEAT TRANSFER ANALYSIS

3.19 TRANSIENT HEAT TRANSFER ANALYSIS

3.19.1 DMAP Sequence for Transient Heat Transfer Analysis

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

1	BEGIN	NO.09 TRANSIENT HEAT TRANSFER ANALYSIS - SERIES N \$
2	FILE	HKGGX=TAPE/HKGG=TAPE \$
3	<u>GP1</u>	GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/ V, N,NOGPDT/V,N,ALWAYS=-1 \$
4	SAVE	HLUSET,NOGPDT \$
5	PURGE	HUSET,GM,HGO,HKAA,HBAA,HPSO,HKFS,HQP,HEST/NOGPDT \$
6	CHKPNT	GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL,HUSET,GM,HGO,HKAA,HBAA, HPSO, HKFS,HQP,HEST \$
7	COND	HLBL5,NOGPDT \$
8	<u>GP2</u>	GEOM2,HEQEXIN/ECT \$
9	CHKPNT	ECT \$
10	PARAML	PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB \$
11	PURGE	PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB \$
12	COND	HP1,NOPCDB \$
13	PLTSET	PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/ V,N, JUMPPLOT=-1 \$
14	SAVE	NSIL,JUMPPLOT \$
15	PRTMSG	PLTSETX// \$
16	PARAM	//C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 \$
17	PARAM	//C,N,MPY/V,N,PFILE/C,N,0/C,N,0 \$
18	COND	HP1,JUMPPLOT\$
19	<u>PLOT</u>	PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,,/PLOTX1/ V,N, NSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
20	SAVE	JUMPPLOT,PLTFLG,PFILE \$
21	PRTMSG	PLOTX1// \$
22	LABEL	HP1 \$
23	CHKPNT	PLTPAR,GPSETS,ELSETS \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

```

24 GP3      GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/C,N,1 $
25 CHKPNT   GPTT,HSLT $
26 TA1      ECT,EPT,BGPD,HSIL,GPTT,CSTM/HEST,,HGPECT,/V,N,HLUSET/ V,N,
            NOSIMP=-1/C,N,1/C,N,123/C,N,123 $
27 SAVE     NOSIMP $
28 CHKPNT   HEST,HGPECT $
29 COND     HLBL1,NOSIMP $
30 PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
31 PARAM     //C,N,ADD/V,N,NOBGG/C,N,1/C,N,0 $
32 EMG      HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,HBELM,HBDICT/V,N,
            NOKGGX/C,N,/V,N,NOBGG $
33 SAVE     NOKGGX,NOBGG $
34 CHKPNT   HKELM,HKDICT,HBELM,HBDICT $
35 COND     JMPKGGX,NOKGGX $
36 EMA      HGPECT,HKDICT,HKELM/HKGGX,GPST $
37 CHKPNT   HKGGX,GPST $
38 LABEL    JMPKGGX $
39 COND     JMPHBGG,NOBGG $
40 EMA      HGPECT,HBDICT,HBELM/HBGG, $
41 CHKPNT   HBGG $
42 LABEL    JMPHBGG $
43 PURGE    HBNN,HBFF,HBAA,HBGG/NOBGG $
44 CHKPNT   HBGG,HBNN,HBFF,HBAA $
45 LABEL    HLBL1 $
46 RMG      HEST,MATPOOL,GPTT,HKGGX/HRGG,HQGE,HKGG/C,Y,TABS/C,Y,SIGMA=0.0/
            V,N,HNLR/V,N,HLUSET $
47 SAVE     HNLR $
48 EQUIV    HKGGX,HKGG/HNLR $

```

TRANSIENT HEAT TRANSFER ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

49	PURGE	HRGG,HRNN,HRFF,HRAA,HRDD/HNLR \$
50	CHKPNT	HRGG,HRNN,HRFF,HRAA,HRDD,HKGG,HQGE \$
51	GP4	CASECC,GEOM4,HEQEXIN,HSIL,GPD,T,BGPD,T,CSTM/RG,,HUSER,ASET/ V, N,HUSER/V,N,MPCF1=-1/V,N,MPCF2=-1/V,N,SINGLE=-1/V,N,OMIT=-1/ V,N,REACT=-1/C,N,O/C,N,123/V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1 \$
52	SAVE	MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NOL,NOA \$
53	PURGE	GM,GMD/MPCF1/HGO,HGOD/OMIT/HKFS,HPSO,HQP/SINGLE \$
54	CHKPNT	GM,RG,HGO,HKFS,HQP,HUSER,GMD,HGOD,HPSO \$
55	COND	HLBL2,NOSIMP \$
56	GPSP	GPL,GPST,HUSER,HSIL/OGPST/V,N,NOGPST \$
57	SAVE	NOGPST \$
58	COND	HLBL2,NOGPST \$
59	OFF	OGPST,,,,,/\$
60	LABEL	HLBL2 \$
61	EQUIV	HKGG,HKNN/MPCF1/HRGG,HRNN/MPCF1/HBGG,HBNN/MPCF1 \$
62	CHKPNT	HKNN,HRNN,HBNN \$
63	COND	HLBL3,MPCF1 \$
64	MCE1	HUSER,RG/GM \$
65	CHKPNT	GM \$
66	MCE2	HUSER,GM,HKGG,HRGG,HBGG,/HKNN,HRNN,HBNN, \$
67	CHKPNT	HKNN,HRNN,HBNN \$
68	LABEL	HLBL3 \$
69	EQUIV	HKNN,HKFF/SINGLE/HRNN,HRFF/SINGLE/HBNN,HBFF/SINGLE \$
70	CHKPNT	HKFF,HRFF,HBFF \$
71	COND	HLBL4,SINGLE \$
72	SC1	HUSER,HKNN,HRNN,HBNN,/HKFF,HKFS,,HRFF,HBFF, \$
73	CHKPNT	HKFS,HKFF,HRFF,HBFF \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N DMAP-DMAP INSTRUCTION NO.

74	LABEL	HLBL4 \$
75	EQUIV	HKFF,HKAA/OMIT \$
76	EQUIV	HRFF,HRAA/OMIT \$
77	EQUIV	HBFF,HBAA/OMIT \$
78	CHKPNT	HKAA,HRAA,HBAA \$
79	COND	HLBL5,OMIT \$
80	<u>SMP1</u>	HUSET,HKFF,,,/HGO,HKAA,HKOO,HLOO,,,,, \$
81	CHKPNT	HGO,HKAA \$
82	COND	HLBLR,HNLR \$
83	<u>SMP2</u>	HUSET,HGO,HRFF/HRAA \$
84	CHKPNT	HRAA \$
85	LABEL	HLBLR \$
86	COND	HLBL5,NOBG \$
87	<u>SMP2</u>	HUSET,HGO,HBFF/HBAA \$
88	CHKPNT	HBAA \$
89	LABEL	HLBL5 \$
90	<u>DPD</u>	DYNAMICS,GPL,HSIL,HUSET/GPLD,HSILD,HUSETD,TFPOOL,HDLT,,,HNLF, HTRL,,HEQDYN/V,N,HLUSET/V,N,HLUSETD/C,N,123 /V,N,NODLT/ C,N, 123/C,N,123/V,N,NONLFT/V,N,NOTRL/C,N,123/C,N,/V,N,NOUE \$
91	SAVE	HLUSETD,NODLT,NONLFT,NOTRL,NOUE \$
92	COND	ERROR1,NOTRL \$
93	EQUIV	HGO,HGOD/NOUE/GM,GMD/NOUE \$
94	PURGE	HPPO,HPSO,HPDO,HPDT/NODLT \$
95	CHKPNT	HUSETD,HEQDYN,TFPOOL,HDLT,HTRL,HGOD,GMD,HNLF,HSILD,GPLD,HPPO, HPSO,HPDO,HPDT \$
96	<u>MTRXIN</u>	CASECC,MATPOOL,HEQDYN,,TFPOOL/HK2PP,,HB2PP/V,N,HLUSETD/ V,N, NOK2PP/C,N,123/V,N,NOB2PP \$
97	SAVE	NOK2PP,NOB2PP \$

TRANSIENT HEAT TRANSFER ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

98  PARAM    //C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NOK2PP $
99  PURGE    HK2DD/NOK2PP/HB2DD/NOB2PP $
100 EQUIV    HKAA,HKDD/KDEKA/HB2PP,HB2DD/NOA/HK2PP,HK2DD/NOA/HRAA,HRDD/
        NOUE $
101 CHKPNT   HK2PP,HB2PP,HK2DD,HB2DD,HKDD,HRDD $
102 COND     HLBL6,NOGPD $
103 (GKAD)    HUSETD,GM,HGO,HKAA,HBA,HRAA,,HK2PP,,HB2PP/HKDD,HBDD, HRDD,
        GMD,HGOD,HK2DD,HM2DD,HB2DD/C,N,TRANRESP/C,N,DISP/C,N, DIRECT/
        C,Y,G=0.0/C,Y,W3=0.0/C,Y,W4=0.0/V,N,NOK2PP/C,N,-1/ V,N,
        NOB2PP/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/ C,N,-1/V,N,
        NOBG/V,N,NOSIMP/C,N,-1 $
104 LABEL    HLBL6 $
105 EQUIV    HK2DD,HKDD/NOSIMP/HB2DD,HBDD/NOGPD $
106 CHKPNT   HKDD,HBDD,HRDD,GMD,HGOD $
107 (TRLG)    CASECC,HUSETD,HDLT,HSLT,BGPD,HSIL,CSTM,HTRL,DIT,GMD,HGOD,,
        HEST,/HPPO,HPSO,HPDO,HPDT,,HTOL/V,N,NOSET/V,N,PDEPDO $
108 SAVE     PDEPDO,NOSET $
109 EQUIV    HPPO,HPDO/NOSET $
110 EQUIV    HPDO,HPDT/PDEPDO $
111 CHKPNT   HPPO,HPDO,HPSO,HTOL,HPDT $
112 (TRHT)    CASECC,HUSETD,HNLFT,DIT,GPTT,HKDD,HBDD,HRDD,HPDT,HTRL/ HUDVT,
        HPNLD/C,Y,BETA=.55/C,Y,TABS=0.0/V,N,HNLR/C,Y,RADLIN=-1 $
113 CHKPNT   HUDVT,HPNLD $
114 (VDR)     CASECC,HEQDYN,HUSETD,HUDVT,HTOL,XYCDB,HPNLD/HOUDV1,HOPNL1/ C,
        N,TRANRESP/C,N,DIRECT/C,N,0/V,N,NOD/V,N,NOP/C,N,0 $
115 SAVE     NOD,NOP $
116 CHKPNT   HOUDV1,HOPNL1 $
117 COND     HLBL7,NOD $
118 (SOR3)    HOUDV1,HOPNL1,,,/HOUDV2,HOPNL2,,, $
119 PARAM    //C,N,MPY/V,N,CARON/C,N,0/C,N,0 $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

120	OFF	HOUDV2,HOPNL2,,,,//V,N,CARDNO \$
121	SAVE	CARDNO \$
122	CHKPNT	HOPNL2,HOUDV2 \$
126	LABEL	HLBL7 \$
127	PARAM	//C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT \$
128	COND	HLBL9,PJUMP \$
129	EQUIV	HUDVT,HUPV/NOA \$
130	COND	HLBL8,NOA \$
131	<u>SDR1</u>	HUSETD,,HUDVT,,HGOD,GMD,HPSO,HKFS,,/HUPV,,HQP/C,N,1/C,N, TRANSNT \$
132	LABEL	HLBL8 \$
133	CHKPNT	HUPV,HQP \$
134	<u>PLTTRAN</u>	BGPDT,HSIL/BGPD,HSIP/V,N,HLUSET/V,N,HLUSEP \$
135	SAVE	HLUSEP \$
136	<u>SDR2</u>	CASECC,CSTM,MPT,DIT,HEQDYN,HSILD,,BGPD,HTOL,HQP,HUPV,HEST, XYCDB,HPPO/HOPPI,HQPI,HOUPI,,HOEF1,HPUGV/C,N,TRANRESP \$
137	SDRHT	HSILD,HUSETD,HUPV,HOEF1,HSLT,HEST,DIT,HQGE,HOLT,/HOEF1X/C,V, TABS/V,N,HNL \$
138	EQUIV	HOEF1X,HOEF1/ALWAYS \$
139	<u>SDR3</u>	HOPPI,HQPI,HOUPI,,HOEF1,/HOPP2,HQPP2,HOUPIV2,,HOEF2, \$
140	CHKPNT	HOPP2,HQPP2,HOUPIV2,HOEF2 \$
141	OFF	HOPP2,HQPP2,HOUPIV2,HOEF2,,//V,N,CARDNO \$
142	SAVE	CARDNO \$
143	COND	HP2,JUMPPLOT \$
144	<u>PLOT</u>	PLTPAR,GPSETS,ELSETS,CASECC,BGPD,HEQEXIN,HSIP,,HPUGV, HGPECT,/ PLOTX2/V,N,HNSIL/V,N,HLUSEP/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE \$
145	SAVE	PFILE \$
146	PRTMSG	PLOTX2// \$

TRANSIENT HEAT TRANSFER ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 9 HEAT

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

147 LABEL HP2 \$
148 XYTRAN XYCDB,HOPP2,HQPP2,HQUPV2,,HOEF2/HXYPLTT/C,N,TRAN/C,N,PSET/V,N,
PFILE/V,N,CARDNO \$
149 SAVE PFILE,CARDNO \$
150 XYPLOT HXYPLTT// \$
151 LABEL HLBL9 \$
152 JUMP FINIS \$
153 LABEL ERROR1 \$
154 PRTPARM //C,N,-1/C,N,HTRD \$
155 LABEL FINIS\$
156 END \$

RIGID FORMATS

3.19.2 Description of DMAP Operations for Transient Heat Transfer Analysis

3. GP1 generates grid point location tables and tables relating internal and external degree of freedom indices.
7. Go to DMAP No. 89 if no grid point definition table.
8. GP2 generates the Element Connection Table.
12. Go to DMAP No. 22 if no plot package is present.
13. PLTSET transforms user input into plot data tables.
15. PRTMSG prints error messages associated with the structure plotter.
18. Go to DMAP No. 22 if no structure-only plots are requested.
19. PLØT generates all plots of the structure without temperature profiles.
21. PRTMSG prints plotter data and engineering data for each generated plot.
24. GP3 generates the table of user defined temperature sets and the tables of static heat flux input data.
26. TAI generates element tables for use in matrix formulation, load generation, and element data recovery.
29. Go to DMAP No. 45 if no structural or boundary elements exist.
32. EMG generates structural element matrix tables and dictionaries for later assembly.
35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.
36. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
39. Go to DMAP No. 42 if no heat capacity matrix is to be assembled.
40. EMA assembles heat capacity matrix $[B_{gg}]$.
46. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the conductivity matrix. ⁹⁹The element-radiation flux matrix, $[Q_{ge}]$, is also generated for use in data recovery.
48. Equivalence the linear heat transfer matrix, $[K_{gg}]$, to the conductivity matrix if no radiation exists.
51. GP4 generates flugs defining members of various displacement sets (USET) and forms the multi-point constraint equations, $[R_g] \{u_g\} = 0$.
55. Go to DMAP No. 60 if no simple elements exist.
56. GPSP determines if possible matrix singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.
58. Go to DMAP No. 60 if no Grid Point Singularity Table.
59. ØFP prints the singularity messages.
61. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[R_{gg}]$ to $[R_{nn}]$, and $[B_{gg}]$ to $[B_{nn}]$ if no multi-point constraints exist.
63. Go to DMAP No. 68 if no multi-point constraints exist.

TRANSIENT HEAT TRANSFER ANALYSIS

64. MCE1 partitions the multi-point constraint equation matrix, $[R_g] = [R_m \ R_n]$, and solves for the multi-point constraint transformation matrix,

$$[G_m] = - [R_m]^{-1} [R_n] .$$

66. MCE2 partitions conductivity and radiation matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array} \right] ,$$

$$[R_{gg}] = \left[\begin{array}{c|c} \bar{R}_{nn} & R_{nm} \\ \hline R_{mn} & R_{mm} \end{array} \right] ,$$

$$B_{gg} = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array} \right] ,$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T] [K_{mn}] + [K_{mn}] [G_m] + [G_m^T] [K_{mm}] [G_m] .$$

The same equation is applied to R_{nn} and B_{nn} .

69. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$, and $[R_{nn}]$ to $[R_{ff}]$ if no single point constraints exist.
71. Go to DMAP No. 74 if no single point constraints exist.
72. SCE1 partitions the matrices as follows:

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array} \right] .$$

R_{nn} and B_{nn} are partitioned in the same manner, except only the ff partitions are saved.

75. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.
76. Equivalence $[R_{ff}]$ to $[R_{aa}]$ if no omitted coordinates.
77. Equivalence $[B_{ff}]$ to $[B_{aa}]$ if no omitted coordinates.
79. Go to DMAP No. 89 if no omitted coordinates are requested.

RIGID FORMATS

80. SMP1 partitions the conductivity matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right] ,$$

solves for the transformation matrix $[G_o]$:

$$[K_{oo}] [G_o] = - [K_{oa}] ,$$

and solves for the reduced conductivity matrix $[K_{aa}]$:

$$[K_{aa}] = [\bar{K}_{aa}] + [K_{ao}] [G_o] .$$

82. Go to DMAP No. 85 if no radiation matrix exists.

83. SMP2 partitions constrained radiation matrix

$$[R_{ff}] = \left[\begin{array}{c|c} \bar{R}_{aa} & R_{ao} \\ \hline R_{oa} & R_{oo} \end{array} \right] ,$$

and performs matrix reduction

$$[R_{aa}] = [\bar{R}_{aa}] + [R_{oa}^T] [G_o] + [G_o^T] [R_{oa}] + [G_o^T] [R_{oo}] [G_o] .$$

86. Go to DMAP No. 89 if no heat capacity matrix, $[B_{ff}]$, exists.

87. SMP2 calculates a reduced heat capacity matrix, $[B_{aa}]$, with the same equation as DMAP No. 83.

90. DPD generates the table defining the displacement sets each degree of freedom belongs to (USETD), including extra points. It prepares the Transfer Function Pool, the Dynamics Load Table, the Nonlinear Function Table, and the Transient Response List.

92. Go to DMAP No. 153 and exit if no time step data was specified.

93. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points were defined.

96. MTRXIN selects the direct input matrices $[K_{pp}^2]$ and $[B_{pp}^2]$.

100. Equivalence $[K_{aa}]$ to $[K_{dd}^1]$ if no direct input stiffness matrices and no extra points; $[B_{pp}]$ to $[B_{dd}^2]$ and $[K_{pp}]$ to $[K_{dd}^2]$ if only extra points are used; and $[R_{aa}]$ to $[R_{dd}]$ if no extra points are used.

102. Go to DMAP No. 194 if no grid point definition table.

TRANSIENT HEAT TRANSFER ANALYSIS

103. GKAD expands the matrices to include extra points and assembles conductivity, capacitance, and radiation matrices for use in Direct Transient Response.

$$[K_{dd}^1] = \begin{bmatrix} K_{aa} & 0 \\ 0 & 0 \end{bmatrix},$$

$$[B_{dd}^1] = \begin{bmatrix} B_{aa} & 0 \\ 0 & 0 \end{bmatrix},$$

$$[R_{dd}] = \begin{bmatrix} R_{aa} & 0 \\ 0 & 0 \end{bmatrix},$$

$$[K_{dd}] = [K_{dd}^1] + [K_{dd}^2],$$

$$[B_{dd}] = [B_{dd}^1] + [B_{dd}^2].$$

(Nonzero values of the parameters W4, G, and W3 are not recommended for use in heat transfer analysis.)

105. Equivalence $[K_{dd}^2]$ to $[K_{dd}]$ and $[B_{dd}^2]$ to $[B_{dd}]$ if no matrices were generated from the structural elements.
107. TRLG generates matrices of heat flux loads versus time. $\{P_p^0\}$, $\{P_s^0\}$, and $\{P_d^0\}$ are generated with one column per output time step. $\{P_d^t\}$ is generated with one column per solution time step, and the Transient Output List is a list of output time steps.
109. Equivalence $\{P_p^0\}$ to $\{P_d^0\}$ if the d and p sets are the same.
110. Equivalence $\{P_d^0\}$ to $\{P_d^t\}$ if the output times are the same as the solution times.
112. TRHT integrates the equation of motion:

$$[B_{dd}] \{\dot{u}\} + [K_{dd}] \{u\} = \{P_d\} + \{N_d\},$$

where $\{u\}$ is a vector of temperatures at any time,
 $\{\dot{u}\}$ is the time derivative of $\{u\}$ ("velocity"),
 $\{P_d\}$ is the applied heat flux at any time step, and
 $\{N_d\}$ is the total nonlinear heat flux from radiation and/or NOLIN data, extrapolated from the previous solution vector.

The output consists of the $[u_d^t]$ matrix containing temperature vectors and temperature "velocity" vectors for the output time steps.

114. VDR processes the user solution set output requests.
117. Go to DMAP No. 126 if no solution set output is desired.
118. SDR3 transforms the requested temperature and nonlinear load values into output SORT2 format.

RIGID FORMATS

120. ØFP formats the temperature, temperature velocity, and heat flux nonlinear loads for printout.
128. Go to DMAP No. 151 and exit if no further output is desired.
129. Equivalence $[u_d]$ to $[u_p]$ if no structure points were input.
130. Go to DMAP No. 132 if no structure points were input.
131. SDR1 recovers the dependent temperatures:

$$\begin{aligned}\{u_o\} &= [G_o^d] \{u_d\} , \\ \begin{pmatrix} u_d \\ u_o \end{pmatrix} &= \{u_f\} , \\ \begin{pmatrix} u_f + u_e \\ u_s \end{pmatrix} &= \{u_n\} , \\ \{u_m\} &= [G_m^d] \{u_f + u_e\} , \\ \begin{pmatrix} u_n + u_e \\ u_m \end{pmatrix} &= \{u_p\} .\end{aligned}$$

The module also recovers the heat flux into the points having single-point constraints.

$$\{q_s\} = - \{P_s\} + [K_{fs}^T] \{u_f\}.$$

134. PLTTRAN coverts the grid point tables to standard plot form when grid points with one degree of freedom are used.
136. SDR2 calculates requested heat flux transfer in the elements and transforms temperatures, velocities, and heat flux loads into output form.
139. SDR3 prepares requested output in SØRT2 order.
141. ØFP formats requested output and places it on the system output file.
143. Go to DMAP No. 147 if no deformed structure plots are requested.
144. PLØT generates plots of the temperature profile on the structure for specified times.
146. PRTMSG prints plotter data and engineering data for structure plots.
148. XYTRAN prepares tables of requested grid point or element output quantities for XYPLØT
150. XYPLØT prepares requested plots of temperatures, velocities, element flux, or applied heat loads versus time.
152. Go to DMAP No. 155 and make normal exit.
154. TRANSIENT HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIONS.

TRANSIENT HEAT TRANSFER ANALYSIS

3.19.3 Case Control Deck and Parameters for Transient Heat Transfer Analysis

The following items relate to subcase definition and data selection for Transient Heat Transfer Analysis:

1. A single subcase must be defined with a single constraint condition.
2. `DLØAD` and/or `NØNLINER` must be used to define a single time-dependent loading condition. The static load cards (`QVECT`, `QVØL`, `QHBDY`, `QBDY1`, and `QBDY2`) can be used to define a dynamic load by using these cards with, or instead of, the `DAREA` cards. The set identification number on the static load cards (field 2) is used in the same manner as the set identification number on the `DAREA` cards (field 2).
3. `TSTEP` must be used to select the time-step intervals to be used for integration and output.
4. If nonzero initial conditions are desired, `IC` must be used to select a `TEMP` set in the Bulk Data Deck.
5. An estimated temperature distribution vector must be defined on `TEMP` cards and selected with a `TEMP (MATERIAL)` request if radiation effects are included.

The following printed output, sorted by print number or element number (`SØRT2`), is available at selected multiples of the integration time step:

1. Temperatures (`THERMAL`) and derivatives of temperatures (`VELØCITY`) for a list of `PHYSICAL` points (grid points and extra scalar points introduced for dynamic analysis) or `SDISPLACEMENT` and `SVELØCITY` for `SØLUTIØN` points (points used in formation of dynamic equation).
2. Nonzero components of the applied load vector (`ØLOAD`) and constrained heat flow (`SPCFØRCE`) for a list of `PHYSICAL` points.
3. Nonlinear load vector for a list of `SØLUTIØN` points.
4. Flux density (`ELFØRCE`) in selected elements.

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The following plotter output is available for Transient Heat Transfer Analysis:

1. Undeformed plot of the structural model.
2. Temperature profiles for selected time intervals.
3. X-Y plot of temperature or derivative of temperature for a PHYSICAL point or SOLUTION point.
4. X-Y plot of the applied load vector, nonlinear load vector, or constrained heat flow.
5. X-Y plot of flux density for an element.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Transient Heat Transfer Analysis:

1. TABS - optional - the real value of this parameter is the absolute reference temperature.
2. SIGMA - optional - the real value of this parameter is the Stefan-Boltzmann constant.
3. BETA - optional - the real value of this parameter is used as a factor in the integration algorithm.
4. RADLIN - optional - a positive integer value of this parameter causes some of the radiation effects to be linearized.

MODAL FLUTTER ANALYSIS

3.20 MODAL FLUTTER ANALYSIS

3.20.1 DMAP Sequence for Modal Flutter Analysis

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NU.

```

1 BEGIN      AERO NO.10 MODAL FLUTTER ANALYSIS SERIES N $
2 FILE       PHIHL=APPEND/AJJL=APPEND/FSAVE=APPEND/CASEYY=APPEND/CLAMAL=
             APPEND/OVG=APPEND/GHHL=APPEND $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/ V,N,
             NOGPDT $
4 SAVE       LUSET,NOGPDT $
5 COND       ERROR1,NOGPDT $
6 CHKPNT     GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
7 PURGE      D1JE,D2JE/NODJE $
8 GP2        GEOM2,EQEXIN/ECT $
9 CHKPNT     ECT $
10 GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $
11 CHKPNT    GPTT $
12 TAL       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N,
             NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
13 SAVE      NOGENL,NOSIMP,GENEL $
14 COND      ERROR1,NOSIMP $
15 PURGE     OGPST/GENEL $
16 CHKPNT    EST,GPECT,GEI,OGPST $
17 PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
18 PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $
19 EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
             N,NOMGG/C,N,/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/ C,Y,
             CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
             CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $
20 SAVE      NOKGGX,NOMGG $
21 CHKPNT    KELM,KDICT,MELM,MDICT $
22 COND      JMPKGGX,NOKGGX $
23 EMA       GPECT,KDICT,KELM/KGGX,GPST $
24 CHKPNT    KGGX,GPST $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

25	LABEL	JMPKGGX \$
26	COND	ERROR1,NOMGG \$
27	EMA	GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 \$
28	CHKPNT	MGG \$
29	COND	LGPWG,GRDPNT \$
30	GPWG	BGPD,CTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS \$
31	DFP	OGPWG,,,,,// \$
32	LABEL	LGPWG \$
33	EQUIV	KGGX,KGG/NOGENL \$
34	CHKPNT	KGG \$
35	COND	LBL11,NOGENL \$
36	SMA3	GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NCSIMP \$
37	CHKPNT	KGG \$
38	LABEL	LBL11 \$
39	GP4	CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPD,CTM/RG,,USET,ASET/ V,N, LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,CMIT/V,N,REACT/C,N,O/ V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID \$
40	SAVE	MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,REPEAT,NOL,NOA \$
41	PARAM	//C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE \$
42	PURGE	GM,GMD/MPCF1/GO,GOD/OMIT/KFS/SINGLE/QPC/NOSR/KLR,KRR,MLR,MRR, DM,MR/REACT \$
43	COND	LBL4,GENEL \$
44	GPSP	GPL,GPST,USET,SIL/OGPST/V,N,NOGPST \$
45	SAVE	NOGPST \$
46	COND	LBL4,NOGPST \$
47	DFP	OGPST,,,,,// \$
48	LABEL	LBL4 \$
49	EQUIV	KGG,KNN/MPCF1/MGG,MNN/MPCF1 \$
50	CHKPNT	KNN,MNN \$
51	COND	LBL2,MPCF1 \$

MODAL FLUTTER ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

52	MCE1	USET, RG/GM \$
53	CHKPNT	GM \$
54	MCE2	USET, GM, KGG, MGG, , /KNN, MNN, , \$
55	CHKPNT	KNN, MNN \$
56	LABEL	LBL2 \$
57	EQUIV	KNN, KFF/SINGLE/MNN, MFF/SINGLE \$
58	CHKPNT	KFF, MFF \$
59	COND	LBL3, SINGLE \$
60	SCE1	USET, KNN, MNN, , /KFF, KFS, , MFF, , \$
61	CHKPNT	KFF, KFS, MFF \$
62	LABEL	LBL3 \$
63	EQUIV	KFF, KAA/OMIT/ MFF, MAA/OMIT \$
64	CHKPNT	KAA, MAA \$
65	COND	LBL5, OMIT \$
66	SMP1	USET, KFF, , , /GO, KAA, KOO, LOO, , , , \$
67	CHKPNT	GO, KAA \$
68	SMP2	USET, GO, MFF/MAA \$
69	CHKPNT	MAA \$
70	LABEL	LBL5 \$
71	COND	LBL6, REACT \$
72	RBMG1	USET, KAA, MAA/KLL, KLR, KRR, MLL, MLR, MRR \$
73	CHKPNT	KLL, KLR, KRR, MLL, MLR, MRR \$
74	RBMG2	KLL/LLL \$
75	CHKPNT	LLL \$
76	RBMG3	LLL, KLR, KRR/DM \$
77	CHKPNT	DM \$
78	RBMG4	DM, MLL, MLR, MRR/MR \$
79	CHKPNT	MR \$

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

80	LABEL	LBL6 \$
81	DPD	DYNAMICS,GPL,SIL,USET/GPLD,SILD,USED,TFPCOL,,,,,EEC,EQDYN/V, N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V, N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE \$
82	SAVE	LUSETD,NOUE,NOEED \$
83	COND	ERROR2,NOEED \$
84	EQUIV	GO,GOD/NOUE/GM,GMD/NOUE \$
85	READ	KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N, NEIGV \$
86	SAVE	NEIGV \$
87	CHKPNT	LAMA,PHIA,MI,OEIGS \$
88	PARAM	//C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 \$
89	OFF	OEIGS,LAMA,,,,//V,N,CARDNO \$
90	SAVE	CARDNO \$
91	COND	ERROR4,NEIGV \$
92	MTRXIN	CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N, NOK2PP/V,N,NOM2PP/V,N,NOB2PP \$
93	SAVE	NOK2PP,NOM2PP,NOB2PP \$
94	PURGE	K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP \$
95	EQUIV	M2PP,M2DD/NOSET/B2PP,B2DD/NOSET/K2PP,K2DD/NOSET \$
96	CHKPNT	K2PP,M2PP,B2PP,K2DD,M2DD,B2DD \$
97	GKAD	USED,GM,GO,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N, CMPLV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V, N,NOM2PP/V,N,NOB2PP/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/ C, N,-1/C,N,-1/C,N,-1/C,N,-1 \$
98	CHKPNT	K2DD,M2DD,B2DD,GOD,GMD \$
99	GKAM	USED,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIDH/ V,N,NOUE/C,Y,LMODES=999999/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N, NOM2PP/V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE/C,Y,KDAMP=-1 \$
100	SAVE	NONCUP,FMODE \$
101	CHKPNT	MHH,BHH,KHH,PHIDH \$
102	APD	EDT,EQDYN,ECT,BGPD,SILD,USED,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA, USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V, N,LUSETA \$

MODAL FLUTTER ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NU.

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103  SAVE      NK,NJ,LUSETA $
104  CHKPNT    EQAERO,ECTA,BGPA,SILA,USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,
           SILGA $
105  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
106  PURGE     PLTSETA,PLTPARA,GPSETSA,ELSETSA/NOPCDB $
107  COND      P2,NOPCDB $
108  PLTSET    PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
           JUMPPLOT=-1 $
109  SAVE      NSIL1,JUMPPLOT $
110  PRTMSG    PLTSETA// $
111  PARAM     //C,N,MPY/V,N,PFILE/C,N,O/C,N,1 $
112  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,O/C,N,1 $
113  COND      P2,JUMPPLOT $
114  PLOT      PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO,,,,/PLOTX2/V,N,
           NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
115  SAVE      PFILE,JUMPPLOT,PLTFLG $
116  PRTMSG    PLOTX2// $
117  LABEL     P2 $
118  COND      ERROR2,NOEED $
119  GI        SPLINE,US ET,CSTMA,BGPA,SIL,ECTA,GM,GO/GTKA/V,N,NK/V,N,LUSET $
120  CHKPNT    GTKA $
121  PARAM     //C,N,ADD/V,N,DESTRY/C,N,O/C,N,1 $
122  AMG       AERO,ACPT/AJJL,SKJ,D1JK,D2JK/V,N,NK/V,N,NJ/V,N,DESTRY $
123  SAVE      DESTRY $
124  CHKPNT    AJJL,SKJ,D1JK,D2JK $
125  COND      NODJE,NODJE $
126  INPUTT2   /D1JE,D2JE,,,/C,Y,POSITION=-1/C,Y,UNITNUM=11/   C,Y,USRLABEL=
           TAPEID $
127  LABEL     NODJE $
128  PARAM     //C,N,ADD/V,N,XQHHL/C,N,1/C,N,0 $

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RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

129	AMP	AJJL,SKJ,D1JK,D2JK,GTKA,PHIDH,D1JE,D2JE,USED,AERO/QHHL,QJHL/ V,N,NOUE/V,N,XQHHL \$
130	SAVE	XQHHL \$
131	CHKPNT	QHHL,QJHL \$
132	PARAM	//C,N,MPY/V,N,NOP/C,N,-1/C,N,1 \$
133	PARAM	//C,N,MPY/V,N,NOP/C,N,1/C,N,1 \$
134	PARAM	//C,N,MPY/V,N,NOH/C,N,0/C,N,1 \$
135	PARAM	//C,N,MPY/V,N,FLOCP/V,Y,NODJE=-1/C,N,0 \$
136	JUMP	LOOPTOP \$
		Top of DMAP Loop
137	LABEL	LOOPTOP \$
138	FA1	KHH,BHH,MHH,QHHL,CASECC,FLIST/FSAVE,KXHH,BXHH,MXHH/V,N,FLOOP/ V,N,TSTART \$
139	SAVE	FLOOP,TSTART \$
140	CEAD	KXHH,BXHH,MXHH,EED,CASECC/PHIH,CLAMA,OCEIGS/V,N,EIGVS \$
141	SAVE	EIGVS \$
142	COND	LBLZAP,EIGVS \$
143	CUND	LBL16,NOH \$
144	VDR	CASECC,EQDYN,USED,PHIH,CLAMA,,/OPHIH,/C,N,CEIGEN/C,N,MODAL/C, N,123/V,N,NOH/V,N,NOP/V,N,FMODE \$
145	SAVE	NOH,NOP \$
146	COND	LBL16,NOH \$
147	OPF	OPHIH,,,,,//V,N,CARDNO \$
148	SAVE	CARDNO \$
149	LABEL	LBL16 \$
150	FA2	PHIH,CLAMA,FSAVE/PHIHL,CLAMAL,CASEYY,OVG/V,N,TSTART/C,Y,VREF= 1.0/C,Y,PRINT=YES \$
151	SAVE	TSTART \$
152	CHKPNT	PHIHL,CLAMAL,CASEYY,OVG \$
153	COND	CONTINUE,TSTART \$
154	LABEL	LBLZAP \$

MODAL FLUTTER ANALYSIS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

155	COND	CONTINUE,FLOOP \$	
156	REPT	LCOFTOP,100 \$	Bottom of DMAP Loop
157	JUMP	ERROR3 \$	
158	LABEL	CONTINUE \$	
159	CHKPNT	OVG \$	
160	PARAML	XYCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOXYCDB \$	
161	COND	NOXYOUT,NOXYCDB \$	
162	XYTRAN	XYCDB,OVG,,,/XYPLTCE/C,N,VG/C,N,PSET/V,N,PFILE/V,N,CARDNO \$	
163	SAVE	PFILE,CARDNO \$	
164	XYPLOT	XYPLTCE// \$	
165	LABEL	NOXYOUT \$	
166	PARAM	//C,N,AND/V,N,PJUMP/V,N,NOP=-1/V,N,JUMPPLOT \$	
167	COND	FINIS,PJUMP \$	
168	MODACC	CASEYY,CLAMAL,PHIHL,CASECC,,/CLAMAL1,CPHIHL,CASEZZ,,/C,N,CEIGN \$	
169	DDR1	CPHIHL,PHIDH/CPHID \$	
170	CHKPNT	CPHID \$	
171	EQUIV	CPHID,CPHIP/NOA \$	
172	COND	LBL14,NOA \$	
173	SDR1	USETD,,CPHID,,,GOC,GMD,,KFS,,/CPHIP,,QPC/C,N,1/C,N,DYNAMICS \$	
174	LABEL	LBL14 \$	
175	CHKPNT	CPHIP,QPC \$	
176	EQUIV	CPHID,CPHIA/NOUE \$	
177	COND	LBLNOE,NOUE \$	
178	VEC	USETA/RP/C,N,D/C,N,A/C,N,E \$	
179	PARTN	CPHID,,RP/CPHIA,,,/C,N,1/C,N,3 \$	
180	LABEL	LBLNOE \$	
181	PARAM	//C,N,PREC/V,N,PREC \$	
182	MPYAD	GTKA,CPHIA,/CPHIK/C,N,1/C,N,1/C,N,0 \$	

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NG.

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183  UMERGE  USETA,CPHIP,/CPHIP/C,N,PS/C,N,P/C,N,SA $
184  UMERGE  USETA,CPHIP,CPHIK/CPHIPA/C,N,PA/C,N,PS/C,N,K $
185  CHKPNT  CPHIPA $
186  UMERGE  USETA,QPC,/QPAC/C,N,PA/C,N,P/C,N,K $
187  CHKPNT  QPAC $
188  SDR2    CASEZZ,CSTMA,MPT,DIT,EQAERO,SILA,,,BGPA,CLAMAL1,QPAC,CPHIPA,
          EST,,,OQPAC1,OCPHIPA,OESCL,OEFC1,PCPHIPA/C,N,CEIGN $
189  CHKPNT  PCPHIPA $
190  OFP     OCPHIPA,OQPAC1,OESCL,OEFC1,///V,N,CARDNO $
191  COND    P3,JUMPPLOT $
192  PLOT    PLTPARA,GPSETSA,ELSETSA,CASEZZ,BGPA,EQAERO,SILGA,,,PCPHIPA,,/
          PLOTX3/V,N,NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
193  PRMSG   PLOTX3// $
194  LABEL   P3 $
195  JUMP     FINIS $
196  LABEL   ERROR1 $
197  PRTPARM //C,N,-1/C,N,FSUBSON $
198  LABEL   ERROR2 $
199  PRTPARM //C,N,-2/C,N,FSUBSON $
200  LABEL   ERROR3 $
201  PRTPARM //C,N,-3/C,N,FSUBSON $
202  LABEL   ERROR4 $
203  PRTPARM //C,N,-4/C,N,FSUBSON $
204  LABEL   FINIS $
205  END     $

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MODAL FLUTTER ANALYSIS

3.20.2 Description of DMAP Operations for Modal Flutter Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables for relating internal and external grid point numbers.
5. Go to DMAP No. 196 and print error message if no grid points are present.
8. GP2 generates Element Connection Table with internal indices.
10. GP3 generates Static Loads Table and Grid Point Temperature Table.
12. TA1 generates element tables for use in matrix assembly and stress recovery.
14. Go to DMAP No. 196 and print error message if no elements have been defined.
19. EMG generates structural element matrix tables and dictionaries for later assembly.
22. Go to DMAP No. 25 if no stiffness matrix is to be assembled.
23. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.
26. Go to DMAP No. 196 and print error message if no mass matrix exists.
27. EMA assembles mass matrix $[M_{gg}]$.
29. Go to DMAP No. 32 if no weight and balance request.
30. GPWG generates weight and balance information.
31. ØFP formats weight and balance information and places it on the system output file for printing.
33. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.
35. Go to DMAP No. 38 if no general elements.
36. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.
39. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$.
43. Go to DMAP No. 48 if general elements present.
44. GPSP determines if possible grid point singularities remain.
46. Go to DMAP No. 48 if no grid point singularities remain.
47. ØFP formats the table of possible grid point singularities and places it on the system output file for printing.
49. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.
51. Go to DMAP No. 56 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.
52. MCE1 partitions multipoint constraint equations $[R_g] = \begin{bmatrix} R_m \\ R_n \end{bmatrix}$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

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54. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \begin{bmatrix} \bar{K}_{nn} & | & K_{nm} \\ \hline - & - & - \\ K_{mn} & | & K_{mm} \end{bmatrix} \quad \text{and} \quad [M_{gg}] = \begin{bmatrix} \bar{M}_{nn} & | & M_{nm} \\ \hline - & - & - \\ M_{mn} & | & M_{mm} \end{bmatrix}$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m] .$$

57. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

59. Go to DMAP No. 62 if no single-point constraints.

60. SCE1 partitions out single-point constraints

$$[K_{nn}] = \begin{bmatrix} K_{ff} & | & K_{fs} \\ \hline - & - & - \\ K_{sf} & | & K_{ss} \end{bmatrix} \quad \text{and} \quad [M_{nn}] = \begin{bmatrix} M_{ff} & | & M_{fs} \\ \hline - & - & - \\ M_{sf} & | & M_{ss} \end{bmatrix}$$

63. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted degrees of freedom.

65. Go to DMAP No. 70 if no omitted coordinates.

66. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \begin{bmatrix} \bar{K}_{aa} & | & K_{ao} \\ \hline - & - & - \\ K_{oa} & | & K_{oo} \end{bmatrix}$$

and solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o] .$

68. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \begin{bmatrix} \bar{M}_{aa} & | & M_{ao} \\ \hline - & - & - \\ M_{oa} & | & M_{oo} \end{bmatrix}$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oo}][G_o] + [G_o^T][M_{oa}] .$$

MODAL FLUTTER ANALYSIS

71. Go to DMAP No. 80 if no free-body supports.

72. RBMG1 partitions out free-body supports

$$[K_{aa}] = \begin{bmatrix} K_{\ell\ell} & K_{\ell r} \\ K_{r\ell} & K_{rr} \end{bmatrix} \quad \text{and} \quad [M_{aa}] = \begin{bmatrix} M_{\ell\ell} & M_{\ell r} \\ M_{r\ell} & M_{rr} \end{bmatrix}$$

74. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

76. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}]$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates and outputs rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}$$

78. RBMG4 forms rigid body mass matrix $[M_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

81. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

83. Go to DMAP No. 198 and print error message if no Eigenvalue Extraction Data.

84. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

85. READ extracts real eigenvalues and vectors from the equation

$$[K_{aa} - \lambda M_{aa}]\{\phi_a\} = 0,$$

calculates rigid body modes by finding a matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D\phi_{ro} \\ \phi_{ro} \end{bmatrix},$$

RIGID FORMATS

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

- 1) Unit value of selected coordinate
- 2) Unit value of largest component
- 3) Unit value of generalized mass

89. ØFP formats the summary of eigenvalues and the summary of eigenvalue extraction information and places them on the system output file for printing.
91. Go to DMAP No. 202 and print error message if no eigenvalues are found.
92. MTRXIN selects the direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$, and $[B_{pp}^2]$.
95. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied.
97. GKAD applies constraints to direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$, and $[B_{pp}^2]$, forming $[K_{dd}^2]$, $[M_{dd}^2]$, and $[B_{dd}^2]$ (see Section 9.3.3 of the Theoretical Manual) and forms $[G_{md}]$ and $[G_{od}]$.
99. GKAM selects eigenvectors to form $[\phi_{dh}]$ and assembles stiffness, mass and damping matrices in modal coordinates:

$$\begin{aligned} [K_{hh}] &= \begin{bmatrix} k_i & 1 & 0 \\ 0 & 1 & 0 \end{bmatrix} + [\phi_{dh}^T][K_{dd}^2][\phi_{dh}] \quad , \\ [M_{hh}] &= \begin{bmatrix} m_i & 1 & 0 \\ 0 & 1 & 0 \end{bmatrix} + [\phi_{dh}^T][M_{dd}^2][\phi_{dh}] \quad , \\ [B_{hh}] &= \begin{bmatrix} b_i & 1 & 0 \\ 0 & 1 & 0 \end{bmatrix} + [\phi_{dh}^T][B_{dd}^2][\phi_{dh}] \quad . \end{aligned}$$

where

<u>KDAMP = 1</u>	<u>KDAMP = -1 (default)</u>
$m_i = \text{modal masses}$	$m_i = \text{modal masses}$
$b_i = m_i \ 2\pi \ f_i \ g(f_i)$	$b_i = 0$
$k_i = m_i \ 4\pi^2 \ f_i$	$k_i = (1+ig(f_i)) \ 4\pi^2 \ f_i^2 m_i$

102. APD processes the aerodynamic data cards from EDT. It adds the k points and the SA points to USETD making USETA. EQAERØ, ECTA, BGPA, CSTMA, GPLA, and SILA are updated to reflect the new elements. AERØ and ACPT reflect the aerodynamic parameters. SILGA is a special SIL for plotting.
107. Go to DMAP No. 117 if no plot package is present.
108. PLTSET transforms user input into a form used to drive structure plotter.
110. PRTMSG prints error messages associated with structure plotter.
113. Go to DMAP No. 117 if no undeformed aerodynamic structure plot request.
114. PLØT generates all requested undeformed aerodynamic structure plots.
116. PRTMSG prints plotter data and engineering data for each undeformed aerodynamic plot generated.

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118. Go to DMAP No. 198 and print error message if no Eigenvalue Extraction Data.
119. GI forms a transformation matrix $[G_{ka}^T]$ which interpolates between aerodynamic (k) and structural (a) degrees of freedom.
122. AMG forms the aerodynamic matrix list $[A_{jj}]$, the area matrix $[S_{kj}]$, and the downwash coefficients $[D_{jk}^1]$ and $[D_{jk}^2]$.
125. Go to DMAP No. 127 if no user-supplied downwash coefficients.
126. INPUTT2 provides the user-supplied downwash factors due to extra points ($[D_{je}^1]$, $[D_{je}^2]$).
129. AMP computes the aerodynamic matrix list related to the modal coordinates as follows:

$$[\phi_{dh}] = \begin{bmatrix} \phi_{ai} & \phi_{ae} \\ \phi_{ei} & \phi_{ee} \end{bmatrix} \quad [G_{ki}] = [G_{ka}^T]^T [\phi_{ai}]$$

$$[D_{jh}^1] \Leftarrow [D_{ji}^1 \mid D_{je}^1] \quad [D_{ji}^1] = [D_{jk}^1]^T [G_{ki}]$$

$$[D_{jh}^2] \Leftarrow [D_{ji}^2 \mid D_{je}^2] \quad [D_{ji}^2] = [D_{jk}^2]^T [G_{ki}]$$

For each (m,k) pair:

$$[D_{jh}] = [D_{jh}^1] + ik[D_{jh}^2]$$

For each group:

$$[Q_{jh}] = [A_{jj}^T]^{-1}_{\text{group}} [D_{jh}]_{\text{group}}$$

$$[Q_{kh}] = [S_{kj}][Q_{jh}]$$

$$[Q_{ih}] = [G_{ki}]^T [Q_{kh}]$$

$$[Q_{hh}] \Leftarrow \begin{bmatrix} Q_{ih} \\ Q_{eh} \end{bmatrix}$$

135. PARAM initializes the flutter loop counter (FL00P) to zero.
136. Go to next DMAP instruction if cold start or modified restart. L00PT0P will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.
137. Beginning of loop for flutter.
138. FA1 computes the total aerodynamic mass matrix $[M_{hh}^x]$, the total aerodynamic stiffness matrix $[K_{hh}^x]$ and the total aerodynamic damping matrix $[B_{hh}^x]$ as well as a looping table FSAVE. For the k-method

$$M_{hh}^x = (k^2/b^2)M_{hh} + (\rho/2) Q_{hh} \quad ,$$

$$K_{hh}^x = K_{hh} \quad ,$$

$$B_{hh}^x = 0 \quad .$$

RIGID FORMATS

140. CEAD extracts complex eigenvalues from the equation

$$[M_{hh}^X p^2 + B_{hh}^X p + K_{hh}^X] \{\phi_h\} = 0$$

and normalizes eigenvectors to unit magnitude of largest component.

142. Go to DMAP No. 154 if no complex eigenvalues found.
143. Go to DMAP No. 149 if no output request for the extra points introduced for dynamic analysis or modal coordinates.
144. VDR prepares eigenvectors for output, using only the extra points introduced for dynamic analysis and modal coordinates.
146. Go to DMAP No. 149 if no output request for the extra points introduced for dynamic analysis or modal coordinates.
147. ØFP formats eigenvectors for extra points introduced for dynamic analysis and modal coordinates and places them on the system output file for printing.
150. FA2 appends eigenvectors to PHIHL, eigenvalues to CLAMAL, Case Control to CASEYY, and V-g plot data to ØVG.
153. Go to DMAP No. 158 if there is insufficient time for another flutter loop.
155. Go to DMAP No. 158 if flutter loop complete.
156. Go to DMAP No. 137 for additional aerodynamic configuration triplet values.
161. Go to DMAP No. 165 if no X-Y plot package is present.
162. XYTRAN prepares the input for requested X-Y plots.
164. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs. time.
167. Go to DMAP No. 204 if no output requests involve dependent degrees of freedom or forces and stresses.
168. MØDACC selects a list of eigenvalues and vectors whose imaginary parts (velocity in input units) are close to a user input list.
169. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$[\phi_d^C] = [\phi_{dh}] [\phi_h]$$

171. Equivalence $[\phi_d^C]$ to $[\phi_p^C]$ if no constraints applied.
172. Go to DMAP No. 174 if no constraints applied.
173. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o^C\} = [G_o^d] \{\phi_d^C\} \quad , \quad \left\{ \begin{matrix} \phi_d^C \\ \phi_o^C \end{matrix} \right\} = \{\phi_f^C + \phi_e^C\} \quad ;$$

$$\left\{ \begin{matrix} \phi_f^C + \phi_e^C \\ \phi_s^C \end{matrix} \right\} = \{\phi_n^C + \phi_e^C\} \quad , \quad \{\phi_m^C\} = [G_m^d] \{\phi_n^C + \phi_e^C\} \quad ,$$

MODAL FLUTTER ANALYSIS

$$\begin{pmatrix} \phi_f^C + \phi_e^C \\ -\phi_m^C \end{pmatrix} = \{\phi_p^C\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$, $\begin{Bmatrix} 0 \\ -q_s \end{Bmatrix} = \{Q_p^C\}$.

176. Equivalence $[\phi_d^C]$ to $[\phi_a^C]$ if no extra points introduced for dynamic analysis.

177. Go to DMAP No. 180 if no extra points present.

178. VEC generates a d-size partitioning vector (RP) for the a and e sets.

179. PARTN performs partition of $[\phi_d^C]$ using RP.

$$\{\phi_d^C\} = \begin{Bmatrix} \phi_a^C \\ \phi_e^C \end{Bmatrix}$$

182. MPYAD recovers the displacements at the aerodynamic points (k).

$$\{\phi_k^C\} = [G_{ka}^T]^T \{\phi_a^C\}$$

184. UMERGE places $\{\phi_k\}$ in its proper place in the displacement vector

$$\{\phi_{pa}^C\} \Leftarrow \begin{Bmatrix} \phi_p^C \\ -\phi_k^C \\ 0 \end{Bmatrix}$$

186. UMERGE is used to expand $\{Q_p^C\}$ to the pa set.

188. SDR2 calculates element forces and stresses ($\emptyset EFC1$, $\emptyset ESC1$) and prepares eigenvectors and single-point forces of constraint for output ($\emptyset CPHIPA$, $\emptyset QPAC1$). It also prepares PCPHIPA for deformed plotting.

190. $\emptyset FP$ formats tables prepared by SDR2 and places them on the system output file for printing.

191. Go to DMAP No. 194 if no deformed aerodynamic structure plots are requested.

192. PL \emptyset T prepares all deformed aerodynamic structure plots.

193. PRTMSG prints plotter data and engineering data for each deformed plot generated.

195. Go to DMAP No. 204 and make normal exit.

197. M \emptyset DAL COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE N \emptyset . 1 - MASS MATRIX REQUIRED FOR M \emptyset DAL FORMULATION.

199. M \emptyset DAL COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE N \emptyset . 2 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.

201. M \emptyset DAL COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE N \emptyset . 3 - ATTEMPT TO EXECUTE MORE THAN 100 L \emptyset OPS.

204. M \emptyset DAL COMPLEX EIGENVALUE ANALYSIS ERROR MESSAGE N \emptyset . 4 - REAL EIGENVALUES REQUIRED FOR M \emptyset DAL FORMULATION.

RIGID FORMATS

3.20.3 Output for Modal Flutter Analysis

The Real Eigenvalue Summary Table and the Real Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues are included even though all may not be used in the modal formulation.

The grid point singularities from the structural model are also output.

A flutter summary for each value of the configuration parameters is printed out unless PRINT=NØ. This shows ρ , k , $1/k$, m , $m \cdot V_{\text{sound}}$, V , g and f for each complex eigenvalue.

V-g and V-f plots may be requested by the XYØUT control cards by specifying the curve type as VG. The "points" are loop numbers and the "components" are G or F.

Printed output of the following types, sorted by complex eigenvalue root number (SØRT1) and (m , k , ρ) may be requested for all complex eigenvalues kept, as either real and imaginary parts or magnitude and phase angle (0° - 360° lead):

1. The eigenvector for a list of PHYSICAL and AERØDYNAMIC points (grid points, extra points, and aerodynamic points) or SØLUTION points (modal coordinates and extra points).
2. Nonzero components of the single-point forces of constraint for a list of PHYSICAL points.
3. Complex stresses and forces in selected elements.

The ØFREQUENCY case control card can select a subset of the complex eigenvectors for data recovery. In addition, undeformed and deformed shapes may be requested. Undeformed shapes may include only structural or structural and aerodynamic elements.

The eigenvectors used in the modal formulation may be obtained for the analysis points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis Rigid Format or by making a modified restart using the Normal Mode Analysis Rigid Format.

3.20.4 Case Control Deck and Parameters for Modal Flutter Analysis

1. Only one subcase is allowed.
2. Desired direct input matrices for stiffness $[K_{pp}^2]$, mass $[M_{pp}^2]$, and damping $[B_{pp}^2]$ must be

MODAL FLUTTER ANALYSIS

selected via the keywords K2PP, M2PP, or B2PP.

3. CMETHØD must be used to select an EIGC card from the Bulk Data Deck.
4. FMETHØD must be used to select a FLUTTER card from the Bulk Data Deck.
5. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.
6. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

The following user parameters are used in Modal Flutter Analysis.

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in SMA2. Not recommended for use in hydroelastic problems.
3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation. To use this option, LMØDES must be set to 0.
5. LMØDES - used unless set to 0. The integer value of this parameter is the number of lowest modes to be used in the modal formulation. The default value will request all modes to be used.
6. NØDJE - optional in modal flutter analysis. A positive integer of this parameter indicates that user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1.
7. P1, P2 and P3 - required in modal flutter analysis when using NØDJE parameter. See Section 5.3.2 for tape operation parameters required by INPUTT2 module. The defaults for P1, P2 and P3 are -1, 11 and TAPEID, respectively.
8. VREF - optional in modal flutter analysis. Velocities are divided by the real value of this parameter to convert units or to compute flutter indices. The default value is 1.0.
9. PRINT - optional in modal flutter analysis. The BCD value, NØ, of this parameter will suppress the automatic printing of the flutter summary for the K method. The default value is YES.

RIGID FORMATS

3.20.5 Modal Flutter Analysis Subsets

Modal flutter analysis contains two subsets (4 and 5), primarily for data checking. Subset 4 checks all data cards. Subset 5 further refines subset 4 to check only the aerodynamic data. A data check of only the structural model can be accomplished by ALTERing in an EXIT after DMAP instruction number 13. A listing of subsets 4 and 5 follow.

MODAL FLUTTER ANALYSIS

3.20.6 DMAP Sequence for Modal Flutter Analysis, Subset 4

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO (SUBSET 4)

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      AERO NO.10 MODAL FLUTTER ANALYSIS SERIES N $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL/V,N,LUSET/ V,N,
              NOGPD,T $
4 SAVE       LUSET,NOGPD,T $
5 COND       ERROR1,NOGPD,T $
6 CHKPNT     GPL,EQEXIN,GPD,T,CSTM,BGPD,T,SIL $
8 GP2        GEOM2,EQEXIN/ECT $
9 CHKPNT     ECT $
10 GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $
11 CHKPNT    GPTT $
12 TA1       ECT,EPT,BGPD,T,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/ V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
13 SAVE      NOGENL,NOSIMP,GENEL $
14 COND      ERROR1,NOSIMP $
39 GP4       CASECC,GEOM4,EQEXIN,SIL,GPD,T,BGPD,T,CSTM/RG,,USET,ASET/ V,N,
              LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/C,N,O/
              V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
40 SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,REPEAT,NOL,NOA $
41 PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $
81 DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,EED,EQDYN/V,
              N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
82 SAVE      LUSETD,NOUE,NOEED $
92 MTRXIN    CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $
93 SAVE      NOK2PP,NOM2PP,NOB2PP $
102 APD      EDT,EQDYN,ECT,BGPD,T,SILD,USETD,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA,
              USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V,
              N,LUSETA $
103 SAVE     NK,NJ,LUSETA $
104 CHKPNT   EQAERO,ECTA,BGPA,SILA,USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,
              SILGA $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO (SUBSET 4)

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

105  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
106  PURGE     PLTSETA,PLTPARA,GPSETSA,ELSETSA/NOPCDB $
107  COND      P2,NOPCDB $
108  PLTSET    PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
             JUMPPLOT=-1 $
109  SAVE      NSIL1,JUMPPLOT $
110  PRTMSG    PLTSETA// $
111  PARAM     //C,N,MPY/V,N,PFILE/C,N,O/C,N,1 $
112  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,O/C,N,1 $
113  COND      P2,JUMPPLOT $
114  PLOT      PLTPARA,GPSETSA,ELSETSA,CAS ECC,BGPA,EQAERO,,,,/PLOTX2/V,N,
             NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
115  SAVE      PFILE,JUMPPLOT,PLTFLG $
116  PRTMSG    PLOTX2// $
117  LABEL     P2 $
118  COND      ERROR2,NOEED $
195  JUMP      FINIS $
196  LABEL     ERROR1 $
197  PRTPARM   //C,N,-1/C,N,FSUBSON $
198  LABEL     ERROR2 $
199  PRTPARM   //C,N,-2/C,N,FSUBSON $
204  LABEL     FINIS $
205  END       $

```

MODAL FLUTTER ANALYSIS

3.20.7 DMAP Sequence for Modal Flutter Analysis, Subset 5

RIGID FORMAT DMAP LISTING
SERIES N

RIGID FORMAT 10 AERO (SUBSET 5)

NASTRAN SOURCE PROGRAM COMPILATION
DMAP-DMAP INSTRUCTION
NO.

```

1 BEGIN      AERO NO.10 MODAL FLUTTER ANALYSIS SERIES N $
2 FILE       PHIHL=APPEND/AJJL=APPEND/FSAVE=APPEND/CASEYY=APPEND/CLAMAL=
             APPEND/OVG=APPEND/QHHL=APPEND $
3 GP1        GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/ V,N,
             NOGPDT $
4 SAVE       LUSET,NOGPDT $
5 COND       ERROR1,NOGPDT $
6 CHKPNT     GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
8 GP2        GEOM2,EQEXIN/ECT $
9 CHKPNT     ECT $
39 GP4        CASECC,GEOM4,EQEXIN,SIL,GPDT,BGPDT,CSTM/RG,,USET,ASET/ V,N,
             LUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/C,N,O/
             V,N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
40 SAVE      MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,REPEAT,NOL,NOA $
41 PARAM     //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $
81 DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,EED,EQDYN/V,
             N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
             N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
82 SAVE      LUSETD,NOUE,NOEED $
83 COND      ERROR2,NOEED $
102 APD       EDT,EQDYN,ECT,BGPDT,SILD,USETD,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA,
             USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V,
             N,LUSETA $
103 SAVE     NK,NJ,LUSETA $
104 CHKPNT   EQAERO,ECTA,BGPA,SILA,USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,
             SILGA $
105 PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
106 PURGE    PLTSETA,PLTPARA,GPSETSA,ELSETSA/NOPCDB $
107 COND     P2,NOPCDB $
108 PLTSET   PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
             JUMPPLOT=-1 $
109 SAVE     NSIL1,JUMPPLOT $

```

RIGID FORMATS

RIGID FORMAT DMAP LISTING SERIES N

RIGID FORMAT 10 AERO (SUBSET 5)

N A S T R A N S O U R C E P R O G R A M C O M P I L A T I O N
DMAP-DMAP INSTRUCTION
NO.

```

110  PRTMSG    PLTSETA// $
111  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,1 $
112  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,0/C,N,1 $
113  COND      P2,JUMPPLOT $
114  PLOT      PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO,,,,,/PLOTX2/V,N,
              NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
115  SAVE      PFILE,JUMPPLOT,PLTFLG $
116  PRTMSG    PLOTX2// $
117  LABEL     P2 $
118  COND      ERROR2,NOEED $
195  JUMP      FINIS $
196  LABEL     ERROR1 $
197  PRTPARM   //C,N,-1/C,N,FSUBSON $
198  LABEL     ERROR2 $
199  PRTPARM   //C,N,-2/C,N,FSUBSON $
204  LABEL     FINIS $
205  END       $

```


PLOTTING

4.1 PLOTTING

NASTRAN provides the capability for generating on any of several different plotters the following kinds of plots:

1. Undeformed geometric projections of the structural model.
2. Static deformations of the structural model by either displaying the deformed shape (alone or superimposed on the undeformed shape), or displaying the displacement vectors at the grid points (superimposed on either the deformed or undeformed shape).
3. Modal deformations (sometimes called mode shapes or eigenvectors) resulting from real eigenvalue analysis by the same options stated in 2 above. Complex modes of flutter analysis may be plotted for any user chosen phase lag.
4. Deformations of the structural model for transient response or frequency response by displaying either vectors or the deformed shape for specified times or frequencies.
5. X-Y graphs of transient response or frequency response.
6. V-f and V-g graphs of flutter analysis.
7. Topological displays of matrices.

Structure plots (items 1-4) are discussed in Section 4.2 while X-Y plots (item 5) are discussed in Section 4.3. Matrix plots are generated by Utility Module SEEMAT described in Section 5 and must be accomplished by altering a Rigid Format or using a DMAP sequence. Requests for structure plots or X-Y plots are accomplished in the Case Control Deck by submitting a structure plot request packet or an X-Y output request packet. The discussion of these packets constitutes most of the remainder of this chapter. The optional PLØTID card is considered to be part of the plot packets (although it must precede any ØUTPUT(PLØT), ØUTPUT(XYØUT), or ØUTPUT(XYPLØT) cards, see page 2.3-38).

In order to actually create plots, a plotter and model name must be specified by the user. The method used to specify this information may vary according to the plot request made, but the actual names used do not vary. In addition, a physical plot tape must be set up by the user. The control cards needed to set up a plot tape are generally installation dependent and are described in Section 5 of the Programmer's Manual. There are two plot tapes (PLT1 and PLT2). It is only necessary to set up the plot tape used by the specified plotter. The number of plots for PLT1 on IBM 360 computers is limited (see Section 5.3.5 of the Programmer's Manual).

The following table is a list of permissible plotter and model names, together with the corresponding plot tapes which must be set up by the user. The underlined items are the default models for each plotter. A model name is generally specified as two items, each having a default value. The default value of the second item is in some cases dependent upon the value specified for the first item. If no plotter is specified by the user, the requested plots will be created for the Stromberg Carlson (SC) model 4020 microfilm plotter.

PLOTTING

Plotter Name	Plot Tape	Plotter Model
BL	PLT1	$\left\{ \begin{matrix} \text{STE} \\ \text{LTE} \end{matrix} \right\}, \underline{30}$
CALCOMP	PLT2	$\left\{ \begin{matrix} 765 \\ 763 \end{matrix} \right\}, \left\{ \begin{matrix} 205 \\ 210 \\ 105 \\ 110 \end{matrix} \right\}$ $\left\{ \begin{matrix} 565 \\ 563 \end{matrix} \right\}, \left\{ \begin{matrix} 205 \\ 210 \\ 105 \\ 110 \\ 305 \\ 310 \end{matrix} \right\}$
DD	PLT2	<u>80</u> , <u>B</u>
EAI	PLT1	<u>3500</u> , $\left\{ \begin{matrix} 30 \\ 45 \end{matrix} \right\}$
NASTPLT	PLT2	$\left\{ \begin{matrix} M \\ T \\ D \end{matrix} \right\}, \left\{ \begin{matrix} 0 \\ T \end{matrix} \right\}$
<u>SC</u>	PLT2	<u>4020</u>

The plotter name, BL, is used for Benson Lechner plotters. The default model is an STE, 30. The first model item may be either STE or LTE, where STE is a short line electroplotter and LTE is a long line electroplotter. The second model item may only equal 30, which is the size of the plotter table in inches. Both the STE and LTE plotters are table plotters.

The plotter name, CALCOMP, is used for California Computer plotters. The default model is a 765, 205. The first model item is the plotter model number as used in California Computer hardware descriptions. The 700 series plotters are those having the ZIP mode and 24 incremental directions. The 500 series plotters are those having only 8 incremental directions. The 600 series may have either 24 or 8 incremental directions. If the user has access to only a 663 or 665 plotter, it should be specified as a 563 or 565 if it has only 8 incremental directions, and as a 763 or 765 if it has 24 incremental directions. The 563 and 763 are both 30-inch drum plotters, while the 565 and 765 are both 12-inch drum plotters.

PLOTTING

The second model item indicates the type of tape transport used with the CALCØMP plotter and the increment size of the plotter. There are two possible increment sizes, .010 and .005 inches. The last two digits of this second model item represent these two possible increment sizes, i.e., 10 = .010 and 05 = .005. The first digit of the second model item represents the type of tape transport attached to the plotter. There are three types of tape transports available. The primary differences among these transports are the number of characters needed to cause one incremental movement on the plotter. Some transports (e.g. the 470, 570 and 750 models) require three characters. These transports can only be attached to the 500 series plotters. Other transports (e.g. the 760 and 770) require two characters for each incremental movement. Still other transports (e.g. the 780) require only one character for each incremental movement. The first digit of the second model item is the number of characters required by the tape transport for each incremental movement. An example of a legitimate CALCØMP model name is (763,105). This represents a 763, 30-inch drum plotter with an increment size of .005 inches, driven by a tape transport requiring only one character for each incremental movement (e.g. a 780 tape transport).

The plotter name, DD, is used for Data Display plotters. The only permissible model is the (80,B) microfilm plotter.

The plotter name, EAI, is used for Electronic Associates Inc. plotters. The first model item is the model number as described in EAI hardware descriptions. The only permissible model is an EAI 3500. This is a table plotter having either a 30-inch or 45-inch plotting surface. The second model item is the size of the plotting surface. The default size is a 30-inch surface, i.e., 3500, 30.

The plotter name, NASTPLT, is used for the NASTRAN General Purpose plotter package. This plotter package is used if the desired plotter is not available in the NASTRAN plotting software. However, if this package is specified, a separate program must be written to interpret the resulting plot tape and create the corresponding plots on the actual plotter desired. The default model is M, 0. The first model item may either be M, T, or D. This indicates the actual plotter is a microfilm, table or drum plotter, respectively. The second model item indicates whether or not the actual plotter has any typing capability: 0 = typing possible, 1 = no typing possible. If no typing capability exists, all printed characters will be drawn. The default plotter type is a microfilm plotter with typing capability. An example of an acceptable model is (T,1). This represents a table plotter having no typing capability. A more detailed description of the

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implications of the NASTRAN General Purpose plotter package is given in Section 6 of the Programmer's Manual.

The plotter name, SC, is used for Stromberg Carlson plotters. The only permissible model is the 4020 microfilm plotter. If the only available plotter model is a 4060, the user should determine if it has a 4020 compatibility package, as is usually the case, so as to avoid using the NASTRAN General Purpose plotter.

The operation of the Structure Plotter is of sufficient theoretical content to warrant inclusion in the Theoretical Manual. Section 13 of the Theoretical Manual provides a discussion of the basic theory and gives some examples of plotter output.

The availability of NASTRAN plotting capability is a function of the particular rigid format as shown in the following table.

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Plotter Availability for the NASTRAN Rigid Formats

Rigid Format	Structure Plotter		Curve Plotter	Matrix Topology Plotter
	Undeformed	Deformed		
1	x	x	x	*
2	x	x		*
3	x	x		*
4	x	x		*
5	x	x		*
6	x	x		*
7	x	x		*
8	x	x	x	*
9	x	x	x	*
10	x	x		*
11	x	x	x	*
12	x	x	x	*
10(AERO)	x	x	x	*

* The matrix topology plotter is not automatically available in any rigid format. Utility module SEEMAT must be altered into the Rigid Format DMAP sequence in order to use this feature (see Section 5.2).

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4.2 STRUCTURE PLOTTING

In order to assist NASTRAN users both in the preparation of the analytical model and in the interpretation of output, the structure plotter provides the following capabilities for undeformed structures:

1. Place a symbol at the grid point locations. (optional)
2. Identify grid points by placing the grid point identification number to the right of the grid point locations. (optional)
3. Identify elements by placing the element identification number and element symbol at the center of each element. (optional)
4. Connect the grid points in a predetermined manner using the structural elements or PLØTEL elements.

The following capabilities are provided for deformed structures:

1. Place a symbol at the deflected grid point location. (optional)
2. Identify the deflected grid points by placing the grid point identification number to the right of the deflected grid point locations. (optional)
3. Connect the deflected grid points in a predetermined manner using the structural elements or PLØTEL elements.
4. Draw lines originating at the undeflected or deflected grid point location, drawn to user-specified scale, representing the X, Y, Z components or resultant summations of the grid point deflections.

The above plots are available in either orthographic, perspective, or stereoscopic projections on several plotters. Stereoscopic plots are normally made only on microfilm plotters since a stereoscopic viewer or projector must be used to obtain the stereoscopic effect. A request for structure plotting is made in the Case Control Deck by means of a plot request packet which includes all cards from an ØUTPUT(PLØT) card to either a BEGIN BULK or ØUTPUT(XYØUT) [or ØUTPUT(XYPLØT)] card. It should be noted that only elements can be plotted. Grid points that are not associated with elements cannot be plotted. Grid points may be connected with PLØTEL elements for plotting purposes.

The data card format is free-field, subject to rules in paragraphs below. The cards are basically sequence dependent even though some interchanging in sequence of defining parameters is permissible. The elements and grid points to be plotted may be defined anywhere in the submittal, but the parameters describing the characteristics of the plot are evaluated on the current basis every time a PLØT or FIND card (see Section 4.2.2.2) is encountered. In order to minimize mistakes, it is suggested that a strict sequence dependency be assumed.

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4.2.1 General Rules

4.2.1.1 Rules for Free-Field Card Specification

1. Only columns 1 thru 72 are available. Any information specified in columns 73 thru 80 will be ignored.
2. If the last character on a card is a comma (not necessarily in column 72), the next card is a continuation of this physical card. Any number of continuation cards may be specified, and together they form a logical card.
3. The mnemonics or values can be placed anywhere on the card, but must be separated by delimiters.
4. The following delimiters are used:
 - a. blank
 - b. , comma
 - c. (left parenthesis
 - d.) right parenthesis
 - e. = equal sign

All of these delimiters can be used as needed to aid the legibility of the data.

4.2.1.2 Plot Request Packet Card Format

In the plot request packet card descriptions presented in Section 4.2.2, the following notations will be used to describe the card format:

1. Upper-case letters must be punched exactly as shown.
2. Lower-case letters indicate that a substitution must be made.
3. Braces { } indicate that a choice of the contents is mandatory.
4. Brackets [] contain an option that may be omitted or included by the user.
5. Underlined options or values are those for which a default option or an initialized (or computed) value was programmed.
6. A physical card consists of information punched in columns 1 through 72 of a card.
7. A logical card may consist of more than one physical card through the use of continuation cards.
8. Numerical values may always be either integer or real numbers, even though a specific type is at times suggested in order to conform to the input in other sections of the program.

4.2.1.3 Plot Titles

Up to four lines of title information will be printed in the lower left-hand corner of each plot. The text for the top three lines is taken from the TITLE, SUBTITLE, and LABEL cards in the

STRUCTURE PLOTTING

Case Control Deck. (See Sections 2.3.2 and 2.3.4 for a description of the TITLE, SUBTITLE, and LABEL cards.) The text for the bottom line may be of two forms depending on the type plot requested. One form contains the word UNDEFØRMED SHAPE. The other form contains the type of plot (statics, modal, etc.), subcase number, load set or mode number, frequency or eigenvalue or time, and (for complex quantities) the phase lag or magnitude.

The sequence number for each plot is printed in the upper corners of each frame. The sequence number is determined by the relative position of each PLØT execution card in the plot package. The date and (for deformed plots) the maximum deformation are also printed at the top of each frame.

4.2.2 Plot Request Packet Card Descriptions

The general form for each card of the plot request packet is shown enclosed in a rectangular box. Description of the card contents then follows for each card.

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4.2.2.1 SET Definition Cards

These cards specify sets of elements, corresponding to portions of the structure, which may be referenced by `PLØT` and `FIND` cards. The SET card is required.

Each set of elements defines by implication a set of grid points connected by those elements. The set may be modified by deleting some of its grid points. The elements are used for creating the plot itself and element labeling while the grid points are used for labeling, symbol printing, and drawing deformation vectors.

SET i	[INCLUDE]	[ELEMENTS]	j ₁ , j ₂ , j ₃ THRU j ₄ , j ₅ , etc.
	[INCLUDE EXCLUDE EXCEPT]	[ELEMENTS GRID POINTS]	k ₁ , k ₂ , k ₃ THRU k ₄ , k ₅ , etc.

i = set identification number (positive integer, unique for each set)

j = element identification numbers or element types

k = element identification numbers or grid point identification numbers
or element types

Permissible element types are:

AXIF2, AXIF3, AXIF4, BAR, CØNE, CØNRØD, HEXA1, HEXA2, FLUID2, FLUID3, FLUID4,
IHEX1, IHEX2, IHEX3, PLØTEL, QDMEM, QDMEM1, QDMEM2, QDPLT, QUAD1, QUAD2, RØD,
SHEAR, SLØT3, SLØT4, TETRA, TØRDRG, TRAPAX, TRAPRG, TRBSC, TRIA1, TRIA2,
TRIAAX, TRIARG, TRMEM, TRPLT, TUBE, TWIST, VISC, WEDGE

ALL may be used to select all permissible element types.

INCLUDE may be used at any time for element information. When used with grid points, INCLUDE can be used only to restore previously EXCLUDEd grid points. It cannot be used to include grid points in the original set of grid points.

EXCLUDE can be used to delete elements or element types. All grid points that are associated with deleted elements are also deleted. EXCLUDE can be used to delete deformation vectors from grid points enumerated after an EXCLUDE command.

EXCEPT is a modifier to an INCLUDE or an EXCLUDE statement.

THRU is used to indicate all of the integers in a sequence of identification numbers, starting with the integer preceding THRU and ending with the integer following THRU. The integers in the range of the THRU statement need not be consecutive, e.g., the sequence 2, 4, 7, 9 may be specified

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as 2 THRU 9.. THRU is not applicable if element types are specified.

Each SET must be a logical card. Redefinition of sets previously defined is not permitted; however, there is no restriction on the number of sets. The sets of identification numbers can be assembled by use of the word ALL, or by individually listing the integers in any order such as 1065, 32, 46, 47, 7020, or by listing sequences using THRU, EXCLUDE, and EXCEPT such as 100 THRU 1000 EXCEPT 182 EXCLUDE 877 THRU 911. Examples of SET cards:

Examples of SET cards:

1. SET 1 INCLUDE 1, 5, 10 THRU 15 EXCEPT 12
(Set will consist of elements 1, 5, 10, 11, 13, 14 and 15)
2. SET 25 = RØD, CØNRØD, EXCEPT 21
(Set will consist of all RØD and CØNRØD elements except element 21)
3. SET 10 SHEAR EXCLUDE GRID PØINTS 20, 30 THRU 60, EXCEPT 35,
36 INCLUDE ELEMENTS 70 THRU 80.
(This set will include all shear elements plus elements 70 thru 80, and the associated grid point set will contain all grid points connected by these elements. Grid points 20, 30 thru 34 and 37 thru 60 will appear on all plots with their symbols and labels, however no deformation vectors will appear at these grid points when VECTØR is commanded.)
4. SET (15) = (15 THRU 100) EXCEPT (21 THRU 25)
(This set will include all elements from 15 to 20 and from 26 to 100).
5. SET 2 = ALL EXCEPT BAR
(This set will include all elements except bars).

NOTE: The equal signs, commas, and parentheses above are delimiters and are not required, because blanks also serve as delimiters.

4.2.2.2 Cards Defining Parameters

These cards specify how the structure will be plotted, i.e., type of projection, view angles, scales, etc. All the multiple choice parameters are defaulted to a preselected choice if not specified. Each parameter requiring a numerical value that is not specified by the user can either be established internally in the program by means of the FIND card or can assume default values. The FIND card is used to request that the program select a SCALE, ØRIGIN, and/or VANTAGE PØINT to allow the construction of a plot in a user-specified region of the paper or film. The FIND card is described at the end of this Section, following the discussion of the associated parameters.

The parameter cards are listed here in a logical sequence; however, they need not be so specified. Any order may be used, but if a parameter is specified more than once, the value or choice stated last will be used. Each parameter may be either an individual card, or any number of them may be combined on one logical card.

All the parameters used in the generation of the various plots will be printed out as part of the output, whether they are directly specified, defaulted or established using the FIND card.

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Initialization of parameters to default values occurs only once. Subsequently, these values remain until altered by a direct input. The only exceptions are the view angles, scale factors, vantage point parameters, and the origins. Whenever the plotter or the method of projection is changed, the view angles are reset to the default values, unless they are respecified by the user. In addition, the scale factors, vantage point parameters, and the origin must be redefined by the user.

PLOTTER plotter name, MØDEL name <table border="1" style="display: inline-table; vertical-align: middle;"> <tr> <td> DENSITY <table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>800</td></tr> <tr><td>556</td></tr> <tr><td>200</td></tr> </table> BPI </td> </tr> </table>	DENSITY <table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>800</td></tr> <tr><td>556</td></tr> <tr><td>200</td></tr> </table> BPI	800	556	200
DENSITY <table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>800</td></tr> <tr><td>556</td></tr> <tr><td>200</td></tr> </table> BPI	800	556	200	
800				
556				
200				

The plotter names and MØDEL names are listed in Section 4.1. The tape density information is used only in print-out and does not control the density of the generated plot tape. To actually specify the tape density, the user must use the customary means of communication established at a given installation between the user and the computer operators. This card is required for plotters other than the SC 4020.

<table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>ØRTHØGRAPHIC</td></tr> <tr><td>PERSPECTIVE</td></tr> <tr><td>STEREØSCØPIC</td></tr> </table> PRØJECTION	ØRTHØGRAPHIC	PERSPECTIVE	STEREØSCØPIC
ØRTHØGRAPHIC			
PERSPECTIVE			
STEREØSCØPIC			

The default option is orthographic projection. See Section 13 of the Theoretical Manual for a discussion of the various projections. This card is optional.

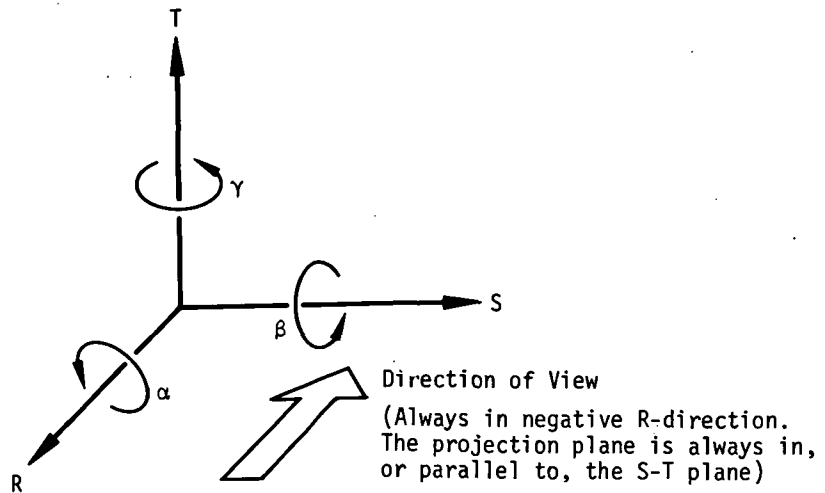
AXES r, s, t <table border="1" style="display: inline-table; vertical-align: middle;"> <tr><td>SYMMETRIC</td></tr> <tr><td>ANTISYMMETRIC</td></tr> </table>	SYMMETRIC	ANTISYMMETRIC
SYMMETRIC		
ANTISYMMETRIC		
VIEW γ , β , α		

$r, s, t = X$ or MX , Y or MY , Z or MZ (where "M" implies the negative axis)

$\gamma, \beta, \alpha =$ three angles of rotation in degrees (real numbers)

These two parameter cards define the orientation of the object in relation to the observer, that is, the angles of view. Both of these cards are optional. Defining the observer's coordinate system as R, S, T and the basic coordinate system of the object as X, Y, Z , the angular relationship between the two systems is defined by the three angles γ, β and α as follows:

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Using the above convention, γ and β represent the angles of turn and tilt. The default values are:

$$\gamma = 34.27^\circ$$

$$\beta = 23.17^\circ \text{ for orthographic and stereoscopic projections}$$

$$0.0^\circ \text{ for perspective projection}$$

$$\alpha = 0.0^\circ$$

The order in which γ , β , and α are specified is critically important as illustrated in Figure 1, at the end of this section. Also, see section 13.1.1 of the Theoretical Manual.

The AXES card can be used to preposition the object in 90° increments in such a manner that only rotations less than 90° are required by the VIEW card to obtain the desired orientation. This is accomplished by entering X, Y, Z, MX, MY or MZ in the fields corresponding to R, S, T axes, where MX, MY and MZ represent the negative X, Y and Z axis directions respectively. The default values are X, Y, Z.

An undeformed or deformed plot of the symmetric portion of an object can be obtained by reversing the sign of the axis that is normal to the plane of symmetry. In the case of multiple planes of symmetry, the signs of all associated planes should be reversed. The ANTISYMMETRIC option should be specified when a symmetric structure is loaded in an unsymmetric manner. This will cause the deformations to be plotted antisymmetrically with respect to the specified plane or

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planes. Since the AXES card applies to all parts (SETS) of a single frame, symmetric and anti-symmetric combinations cannot be made with this card (see the symmetry option on the PLOT execution card in Section 4.2.2.3).

MAXIMUM DEFORMATION d

This card must always be included if a deformed structure is to be plotted. The value of d represents the length to which the maximum displacement component is scaled in each subcase. The maximum deformation of the structure must be specified in units of the structure (not inches of paper). This data is necessary since the actual deformations are usually too small to be distinguishable from the undeformed structure if they were plotted to true scale. If FIND card parameters are to be based on the deformed structure, the FIND card must be preceded by the MAXIMUM DEFORMATION card.

SCALE a[, b]

a = real number representing scale to which the model is drawn

b = ratio of model size/real object size (stereoscopic projection only)

For orthographic or perspective projections, the scale "a" is the ratio of the plotted object in inches to the real object in the units of the structural model, i.e., one inch of paper equals one unit of structure. For stereoscopic projection, the stereoscopic effect is enhanced by first reducing the real object to a smaller model (scale "b"), and then applying scale "a". The ratio of plotted/real object is then the product $a \times b$. A scale must be defined in order to make a plot; however, the SCALE card is not recommended for general use. See the FIND card described at the end of this Section in order to have the scale determined automatically.

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ØRIGIN i, u, v

i = origin identification number (any positive integer)

u = horizontal displacement of paper origin from RST origin

v = vertical displacement of paper origin from RST origin

In the transformation performed for any of the three projections, the origins of both the object (XYZ system) and of the observer (RST system) are assumed to be coincident.

This card refers to the paper origin. It represents the displacement of the paper origin (lower left hand corner) from the RST origin. The units are inches and are not subject to the scaling of the plotted object. The ØRIGIN card is not recommended for general use. See the FIND card described at the end of this Section in order to have the origin located so as to place the plotted object in the center of the image area.

Ten (10) origins are permitted to be active at one time. However, any one can be redefined at any time. An eleventh origin is also provided if more than 10 origins are erroneously defined (i.e., only the last of these surplus origins will be retained). CAUTION: when a new projection or plotter is called for, all previously defined origins are deleted.

VANTAGE PØINT $r_o, s_o, t_o [, s_{or}]$

(perspective and stereoscopic projections only)

r_o = R-coordinate of the observer

s_o = S-coordinate of the observer in perspective projection or
S-coordinate of the left eye of the observer in the stereoscopic projection

t_o = T-coordinate of the observer

s_{or} = S-coordinate of the right eye of the observer in the stereoscopic (not needed in perspective) projection

This card defines the location of the observer with respect to the structural model. A vantage point is required for either perspective or stereoscopic projection. The VANTAGE PØINT card is not recommended for general use. See the FIND card described at the end of this Section. A theoretical description of vantage point is contained in Section 13 of the Theoretical Manual.

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PRØJECTION PLANE SEPARATIØN d_o

(perspective and stereoscopic projections only)

This card specifies the R-direction separation of the observer and the projection plane.

The PRØJECTION PLANE SEPARATIØN card is not recommended for general use. See the FIND card described at the end of this Section. The card may be omitted if VANTAGE PØINT is included on the FIND card. A theoretical description of projection plane separation is contained in Section 13 of the Theoretical Manual.

ØCULAR SEPARATIØN $\left\{ \frac{2.756}{os} \right\}$

(stereoscopic projection only)

Ocular separation - S-coordinate separation of the two vantage points in the stereoscopic projection is defaulted to 2.756 inches which is the separation used in the standard stereoscopic cameras and viewers (70mm). It is recommended that the default value be used.

CAMERA $\left\{ \begin{array}{l} \text{FILM} \\ \text{PAPER} \\ \text{BØTH} \end{array} \right\} \left[, \text{BLANK FRAMES } \left\{ \begin{array}{l} n \\ 1 \end{array} \right\} \right]$

(microfilm plotters only)

This card offers three options of different cameras or combinations:

type = FILM - 35mm or 16mm film (positive or negative images)

type = PAPER - positive prints

type = BØTH - positive prints and 35mm or 16mm film

The request for a 35mm or 16mm camera and positive or negative images must be communicated to the plotter operator through normal means of communications at the installation. Insertion of blank frames between plots is optional and is applicable only to plots generated on film. The type option must be FILM or BØTH if blank frames are desired. The plotter must be operated in the manual mode in order to have blank frames inserted between positive prints. If blank frames are desired only on film, and not on paper, the plotter must be operated in the automatic mode. The

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default values are type = PAPER, n = 1. This card is completely optional.

PAPER SIZE { a } { x } { b } [, TYPE { BCD value }] { 8.5 } { BY } { 11.0 } { VELLUM }
--

(table plotters only)

a = horizontal size of paper in inches

b = vertical size of paper in inches

name = any BCD value desired by user for identification purposes.

The default parameters are 8.5 x 11.0, type VELLUM. This card is completely optional.

PEN { i } [, SIZE { j }] [, COLOR { name }] { 1 } [, SIZE { 1 }] [, COLOR { BLACK }]
--

(table plotters only)

i = pen designation number

j = pen size number (0 thru 3)

name = color desired

This card generates a message on the printed output which may be used to inform the plotter operator as to what size and which color pen point to mount in the various pen holders. The actual number of pens available will depend on the plotter hardware configuration at each installation. This card does not control the pen used in generating the plot (see the PEN option on the PLOT execution card in Section 4.2.2.3). The PEN card is optional, and is not appropriate for microfilm plotters.

The pen designations vary on various plotters; therefore, the designation numbers used here are only the pointers to true identification of the pens. The following table summarizes these pen designations and the actual pen numbers on the plotters used.

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NASTRAN Pen Designation	PLOTTER Pen Number	
	EAI 3500	All Others
1	0	1
2	1	2
3	2	3
4	3	4
5	4	1
6	5	2
7	6	3
8	7	4

FIND [SCALE],[ØRIGIN i],[VANTAGE PØINT],[SET j],[REGION le,be,re,te]

i = origin identification number (any positive integer).

j = set identification number (any positive integer).

le = fractional distance of left edge of plot region from the lower left corner of the image area (default value = 0).

be = fractional distance of bottom edge of plot region from the lower left corner of the image area (default value = 0).

re = fractional distance of right edge of plot region from the lower left corner of the image area (default value = 1.).

te = fractional distance of top edge of plot region from the lower left corner of the image area (default value = 1.).

The FIND card requests the structure plotter to compute any of the parameters SCALE, ØRIGINi, and/or VANTAGE PØINT indicated by the user based on (a) the plotter requested on the PLØTTER card, (b) the projection requested on the PRØJECTION card, (c) SETj and REGION le, be, re, te requested on the FIND card, (d) the orientation requested on the VIEW and/or AXES card(s), (e) the deformation scaling requested on the MAXIMUM DEFØRMATION card, and (f) the paper size for table plotters as requested on the PAPER SIZE card. All dependencies on which a FIND card is based must precede the FIND card.

Any one, two, or all three parameters may be computed by the program by using this card, provided that the parameters not requested have already been defined. If no set is specified on this card, the first set defined is used by default. If no options are specified on the FIND card, a SCALE and VANTAGE PØINT are selected and ØRIGIN 1 is located, using the first defined SET, so that the plotted object is located within the image area. The plot region is defined as some fraction of the image area (image area = 0, 0, 1., 1. and first quadrant = .5, .5, 1., 1.). The image area is located inside the margins on the paper. Each FIND card must be one (1) logical card. The FIND card is recommended for general use.

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4.2.2.3 PLØT Execution Card

PLØT	$\left\{ \begin{array}{l} \text{STATIC} \\ \text{MØDAL} \\ \text{CMØDAL} \\ \text{FREQUENCY} \\ \text{TRANSIENT} \end{array} \right\}$	$\left\{ \begin{array}{l} \text{DEFØRMATION} \\ \text{VELOCITY} \\ \text{ACCELERATION} \end{array} \right\}$	$[i1, i2 \text{ THRU } i3, \text{ etc.}]$	$\left\{ \begin{array}{l} \text{RANGE } f1, f2 \\ \text{RANGE } \lambda 1, \lambda 2 \\ \text{TIME } t1, t2 \end{array} \right\}$	$\left\{ \begin{array}{l} \text{PHASE LAG } \phi \\ \text{MAGNITUDE} \end{array} \right\}$
[MAXIMUM DEFØRMATION d],					
$[SET j1][ØRIGIN k1] \left\{ \begin{array}{l} \text{SYMMETRY} \\ \text{ANTISYMMETRY} \end{array} \right\} w \left\{ \begin{array}{l} \text{PEN} \\ \text{DENSITY} \end{array} \right\} p [SYMBOLS m[, n]] \left[\begin{array}{l} \text{LABEL} \left[\begin{array}{l} \text{GRID PØINTS} \\ \text{ELEMENTS} \\ \text{BØTH} \end{array} \right] \right]$					
$\left[\begin{array}{l} \text{SHAPE} \\ \text{VECTØR } v \\ \text{SHAPE, VECTØR } v \end{array} \right],$					
[SET j2][ØRIGIN k2] etc.					

This logical card will cause one picture to be generated for each subcase, mode or time step requested, using the current parameter values. If only the word PLØT appears on the card, a picture of the undeformed structure will be prepared using the first defined set and the first defined origin. The available plot options and their meanings are:

1. **STATIC** - Plot static deformations in Rigid Formats 1, 2, 4, 5, 6 and 14.
- MØDAL** - Plot mode shapes in Rigid Formats 3, 5, 13 and 15.
- CMØDAL** - Plot mode shapes in Rigid Formats 7 and 10.
- FREQUENCY** - Plot frequency deformations in Rigid Formats 8 and 11.
- TRANSIENT** - Plot transient deformations in Rigid Formats 9 and 12.
2. **DEFØRMATION** - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases. See SHAPE and VECTØR for use of "0" command.
- VELOCITY** - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases.
- ACCELERATION** - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases.
3. **i1, i2, ...** - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases. See SHAPE and VECTØR for use of "0" (underlay) command.
4. **RANGE** - Refers to range of eigenvalues (Rigid Format 5) or frequencies (Rigid Formats 3, 7, 8, 10 and 11), using requested subcases, for which plots will be prepared.

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- TIME - Refers to time interval, using requested subcases and output time steps, for which plots will be prepared (Rigid Formats 9 and 12).
5. PHASE LAG - Real number, ϕ , in degrees (default is 0.0). The plotted value is $u_R \cos \phi - u_I \sin \phi$, where u_R and u_I are the real and imaginary parts of the response quantity (Rigid Formats 7, 8, 10 and 11).
- MAGNITUDE - Plotted value is $\sqrt{u_R^2 + u_I^2}$.

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6. **MAXIMUM DEFORMATION** - Real number following is used as the maximum displacement component in scaling the displacements for all subcases. Each subcase is separately scaled according to its own maximum if this item is absent.
7. **SET** - Integer following identifies a set which defines the portion of the structure to be plotted. Default is first set defined.
8. **ORIGIN** - Integer following identifies the origin to be used for the plot. Default is first origin defined.
9. **SYMMETRY w** - Prepare an undeformed or deformed plot of the symmetric portion of the object which is defined by SET j. This symmetric portion will be located in the space adjacent to the region originally defined by ORIGIN k, and will appear as a reflection about the plane whose normal is oriented parallel to the coordinate direction w.
- ANTISYMMETRY w** - Prepare a deformed plot of the symmetric portion of the antisymmetrically loaded object which is defined by SET j. This symmetric portion will be located in the space adjacent to the region originally defined by ORIGIN k, and will appear as a reflection of the antisymmetrically deformed structure about the plane whose normal is oriented parallel to the coordinate direction w.

The symbol w may specify the basic coordinates X, Y, or Z or any combination thereof. This option allows the plotting of symmetric and/or antisymmetric combinations, provided that an origin is selected for the portion of the structure defined by the bulk data that allows sufficient room for the complete plot. This does not permit the combination of symmetric and antisymmetric subcases, as each plot must represent a single subcase. In the case of a double reflection, the figure will appear as one reflected about the plane whose normal is parallel to the first of the coordinates w, followed by a reflection about the plane whose normal is oriented parallel to the second of the coordinates w. This capability is primarily used in the plotting of structures that are loaded in a symmetric or an antisymmetric manner. The plane of symmetry must be one of the basic coordinate planes.

10. **PEN** - Integer following controls the internal NASTRAN pen number (see table in Section 4.2.2.2) that is used to generate the plot on table plotters.
- DENSITY** - Integer following specifies line density for film plotters. A line density of d is d times heavier than a line density of 1.
11. **SYMBOLS m[,n]** - All of the grid points associated with the specified set will have symbol m overprinted with symbol n printed at its location. If n is not specified, only symbol m will be printed. Grid points excluded from the set will not have a symbol. Grid points in an undeformed underlay will be identified with symbol 2.

Following is a table of symbols available on each plotter. Symbols that are not available on a given plotter are defaulted to a similar symbol indicated in parentheses.

SYMBOL Nº. m or n	SYMBOL	AVAILABILITY		
		EAI 3500	SC4020	All Others
0	no symbol	X	X	X
1	X	X	X	X
2	*	X	X	X
3	+	X	X	X
4	-	X	X	X
5	.	X	X	X
6	○	X	X	X
7	□	X	X	X
8	◇	X	(7)	X
9	△	(7)	(7)	X

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12. LABEL GRID POINTS - All the grid points associated with the specified set have their identification number printed to the right of the undeflected or deflected location (undeflected location in the case of superimposed plots).

LABEL ELEMENTS - All the elements included in the specified set are identified by the element identification number and type at the center of each element (undeflected location in the case of superimposed plots).

LABEL BOTH - Label both the grid points and elements.

Labels for element types are given in the following table:

Element Type	Plot Label		Element Type	Plot Label
AERØ	AE		QUAD1	Q1
AXIF2	A2		QUAD2	Q2
AXIF3	A3		RØD	RD
AXIF4	A4		SHEAR	SH
BAR	BR		SLØT3	S3
CØNE	CN		SLØT4	S4
CØNRØD	CR		TETRA	TE
HEXA1	H1		TØRDRG	TR
HEXA2	H2		TRAPAX	T4
FLUID2	F2		TRAPRG	TA
FLUID3	F3		TRBSC	TB
FLUID4	F4		TRIAAX	T3
IHEX1	XL		TRIA1	T1
IHEX2	XQ		TRIA2	T2
IHEX3	XC		TRIRC	T1
PLØTEL	PL		TRMEM	TM
QDMEM	QM		TRPLT	TP
QDMEM1	QM		TUBE	TU
QDMEM2	QM		TWIST	TW
QDPLT	QP		VISC	VS
			WEDGE	WG

13. SHAPE - All the elements included in the specified set are shown by connecting the associated grid points in a predetermined manner.

Both deformed and undeformed shapes may be specified. All of the deformed shapes relating to the subcases listed may be underlaid on each of their plots by including "0" with the subcase string on the PLØT card. The undeformed plot will be drawn using PEN 1 or DENSITY 1 and symbol 2 (if SYMBØLS is specified).

14. VECTØR v - A line will be plotted at the grid points of the set, representing in length and direction the deformation of the point.

Vectors representing the total deformation or its principal components may be plotted by insertion of the proper letter(s) for variable v. Possible vector combinations are:

- X or Y or Z - requesting individual components
- XY or XZ or YZ - requesting 2 specified components
- XYZ - requesting all 3 components
- RXY or RXZ or RYZ - requesting vector sum of 2 components
- R - requesting total vector deformation
- N - used with any of the above combinations to request no underlay shape be drawn.

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All plots requesting the VECTØR option shall have an underlay generated of the undeformed shape using the same sets, "PEN 1" or "DENSITY 1," and symbol 2 (if SYMBOLS is specified). If "SHAPE" and "VECTØR" are specified, the underlay will depend on whether "0" is used with DEFØRMATION. It will be the deformed shape when not used and will be both deformed and undeformed shapes when it is used. The part of the vector at the grid point will be the tail when the underlay is undeformed and the head when it is deformed. If the "N" parameter is used, no shape will be drawn but other options such as SYMBOLS will still be valid.

Examples of PLØT Cards

1. PLØT

Undeformed SHAPE using first defined SET, first defined ØRIGIN and PEN 1 (or DENSITY 1).

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2. PLOT SET 3 ORIGIN 4 PEN 2 SHAPE SYMBOLS 3 LABEL

Undeformed SHAPE using SET 3, ORIGIN 4, PEN 2 (or DENSITY 2) with each grid point of the set having a + placed at its location, and its identification number printed adjacent to it.

3. PLOT MODAL DEFORMATION 5 SHAPE

Modal deformations as defined in subcase 5 using first defined SET, first defined ORIGIN, and PEN 1 (or DENSITY 1).

4. PLOT STATIC DEFORMATION 0, 3 THRU 5, 8 PEN 4, SHAPE

STATIC deformations as defined in subcases 3, 4, 5 and 8, deformed SHAPE; drawn with PEN 4, using first defined SET and ORIGIN, underlayed with undeformed SHAPE drawn with PEN 1. This command will cause four plots to be generated.

5. PLOT STATIC DEFORMATION 0 THRU 5,

SET 2 ORIGIN 3 PEN 3 SHAPE,

SET 2 ORIGIN 4 PEN 4 VECTORS XYZ SYMBOLS 6,

SET 35 SHAPE

Deformations as defined in subcases 1, 2, 3, 4, and 5, undeformed underlay with PEN 1, consisting of SET 2 at ORIGIN 3, SET 2 at ORIGIN 4 (with an * placed at each grid point location), and SET 35 at ORIGIN 4. Deflected data as follows: SHAPE using SET 2 at ORIGIN 3 (PEN 3) and SET 35 at ORIGIN 4 (PEN 4); 3 VECTORS (X, Y and Z) drawn at each grid point of SET 2 at ORIGIN 4 (PEN 4) (less any excluded grid points), with O placed at the end of each vector.

6. PLOT STATIC DEFORMATIONS 0, 3, 4,

SET 1 ORIGIN 2 DENSITY 3 SHAPE,

SET 1 SYMMETRY Z SHAPE,

SET 2 ORIGIN 3 SHAPE,

SET 2 SYMMETRY Z SHAPE

Static deformations as defined in subcases 3 and 4, both halves of a problem solved by symmetry using the X-Y principal plane as the plane of symmetry. SET 1 at ORIGIN 2 and SET 2 at ORIGIN 3, with the deformed shape plotted using DENSITY 3 and the undeformed structure plotted using DENSITY 1. The deformations of the "opposite" half will be plotted to correspond to symmetric loading. This command will cause two plots to be generated.

7. PLOT TRANSIENT DEFORMATION 1, TIME 0.1, 0.2, MAXIMUM DEFORMATION 2.0, SET 1, ORIGIN 1,

PEN 2, SYMBOLS 2, VECTOR R

Transient deformations as defined in subcase 1 for time = 0.1 to time = 0.2, using set 1 at origin 1. The undeformed shape using pen or density 1 with an * at each grid point location will be drawn as an underlay for the resultant deformation vectors using pen or density 2 with an * typed at the end of each vector drawn. In addition a plotted value of 2.0 will be used for the single maximum deformation occurring on any of the plots produced. All other deformations on all other plots will be scaled relative to this single maximum deformation. This command will cause a plot to be generated for each output time step which lies between 0.1 and 0.2.

8. PLOT MODAL DEFORMATION PHASE LAG 90. SET 1 VECTOR R

The imaginary part of the complex mode shape will be plotted for set 1.

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4.2.3 Summary of Structure Plot Request Packet Cards

SET Definition - Required

SET i [INCLUDE][ELEMENTS] j_1, j_2, j_3 THRU j_4, j_5 , etc.

[INCLUDE
EXCLUDE
EXCEPT] [ELEMENTS
GRID POINTS] k_1, k_2, k_3 THRU k_4, k_5 , etc.

Parameter Definition - Optional, except as noted

PLOTTER plotter name, MODEL name [DENSITY $\left\{ \begin{matrix} 800 \\ 556 \\ 200 \end{matrix} \right\}$ BPI]

(Required if not SC-4020)

[ORTHOGRAPHIC
PERSPECTIVE
STEREOSCOPIC] PROJECTION

AXES r, s, t [{SYMMETRIC
ANTISYMMETRIC}]

VIEW γ, β, α

SCALE a[, b] (Required if not on FIND card)

ORIGIN i, u, v (Required if not on FIND card)

VANTAGE POINT r_o, s_o, t_o [, s_{or}]

(Required for perspective and stereoscopic projections if not on FIND card)

PROJECTION PLANE SEPARATION d_o

(Required for perspective and stereoscopic projections if VANTAGE POINT not on FIND card)

OCULAR SEPARATION $\left\{ \begin{matrix} 2.756 \\ os \end{matrix} \right\}$

MAXIMUM DEFORMATION d

(Required if deformed shapes are to be drawn)

PEN $\left\{ \begin{matrix} i \\ 1 \end{matrix} \right\}$ [, SIZE $\left\{ \begin{matrix} j \\ 1 \end{matrix} \right\}$] [, COLOR {name
BLACK}]

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CAMERA $\left\{ \begin{array}{l} \text{FILM} \\ \text{PAPER} \\ \text{BOTH} \end{array} \right\} \left[, \text{BLANK FRAMES } \left\{ \begin{array}{l} n \\ 1 \end{array} \right\} \right]$

PAPER SIZE $\left\{ \begin{array}{l} a \\ 8.5 \end{array} \right\} \left\{ \begin{array}{l} x \\ BY \end{array} \right\} \left\{ \begin{array}{l} b \\ 11.0 \end{array} \right\} \left[, \text{TYPE } \left\{ \begin{array}{l} \text{BCD value} \\ \text{VELLUM} \end{array} \right\} \right]$

FIND Card - Optional

FIND $\left[\text{SCALE} \right], \left[\text{ORIGIN } i \right], \left[\text{VANTAGE POINT} \right], \left[\text{SET } j \right], \left[\text{REGION } le, be, re, te \right]$

PLOT Execution Card - Required

$\left[\left\{ \begin{array}{l} \text{STATIC} \\ \text{MODAL} \\ \text{CMODAL} \\ \text{TRANSIENT} \\ \text{FREQUENCY} \end{array} \right\} \right] \left[\left\{ \begin{array}{l} \text{DEFORMATION} \\ \text{VELOCITY} \\ \text{ACCELERATION} \end{array} \right\} \right] [i1, i2 \text{ THRU } i3, i4, \text{ etc.}] \left[\left\{ \begin{array}{l} \text{RANGE } f1, f2 \\ \text{RANGE } \lambda 1, \lambda 2 \\ \text{TIME } t1, t2 \end{array} \right\} \right]$

$\left[\left\{ \begin{array}{l} \text{PHASE LAG } \phi \\ \text{MAGNITUDE} \end{array} \right\} \right] [\text{MAXIMUM DEFORMATION } d] ,$

$[\text{SET } j1] [\text{ORIGIN } k1] \left[\left\{ \begin{array}{l} \text{SYMMETRY} \\ \text{ANTISYMMETRY} \end{array} \right\} w \right] \left[\left\{ \begin{array}{l} \text{PEN} \\ \text{DENSITY} \end{array} \right\} p \right] [\text{SYMBOLS } m[,n]]$

$\left[\text{LABEL } \left[\begin{array}{l} \text{GRID POINTS} \\ \text{ELEMENTS} \\ \text{BOTH} \end{array} \right] \right] \left[\begin{array}{l} \text{SHAPE} \\ \text{VECTOR } v \\ \text{SHAPE, VECTOR } v \end{array} \right] .$

$[\text{SET } j2] [\text{ORIGIN } k2] \dots , \text{ etc.}$

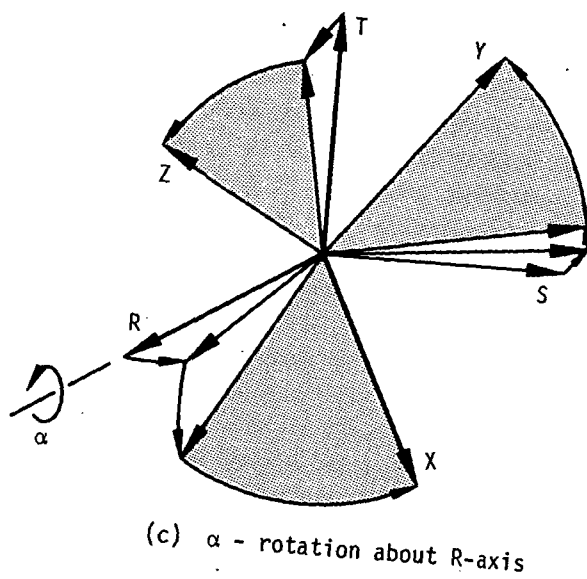
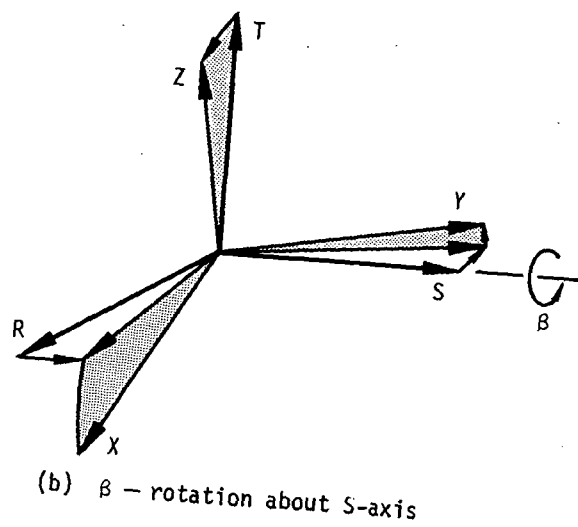
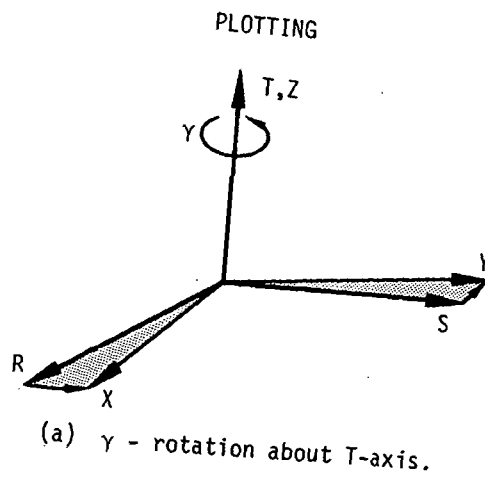


Figure 1. Plotter coordinate system-model orientation.

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4.3 X-Y OUTPUT

In rigid formats used for transient response, frequency response (including random response), and flutter analysis, the amount of output data generated is voluminous. In order to aid the user in assimilating this vast amount of data, the X-Y output processing modules XYTRAN and XYPLØT have been provided. The primary purpose of these modules is to generate plotted graphs of $y(x)$ where x is frequency, time, or velocity and y is any response quantity selected by the user for observation. The user is not required to specify any parametric data for the X-Y plotter; however, he may do so if he wishes in order to obtain desired scales, regions of observation, etc.

In addition to (or in place of) the plots, X-Y tabular output may be printed or punched, and summary data (e.g., maximum and minimum values and locations of these values) may be obtained for any X-Y output.

The X-Y output described above is obtained by the user via the X-Y output request packet of the Case Control Deck. This packet includes all cards between ØUTPUT(XYPLØT) [or ØUTPUT(XYØUT)] and either BEGIN BULK or ØUTPUT(PLØT). The remainder of this section describes the X-Y output request data cards and the rules for writing them. Examples are provided to illustrate the use of this feature.

4.3.1 X-Y Plotter Terminology

A single set of plotted X-Y pairs is known as a "curve". Curves are the entities that the user requests to be plotted. The surface (paper, microfilm frame, etc.) on which one or more curves is plotted is known as a "frame". Curves may be plotted on a whole frame, an upper half frame, or a lower half frame. Grid lines, tic marks, axes, axis labeling and other graphic control items may be chosen by the user. The program will select defaults for parameters not selected by the user.

Only three cards are required for an X-Y plot request. The required cards are:

1. X-Y output request packet identifier - ØUTPUT(XYPLØT) or ØUTPUT(XYØUT).
2. Plotter selection card.
3. At least one command operation card.

The terms ØUTPUT(XYPLØT) and ØUTPUT(XYØUT) are interchangeable and either form may be used for any of the X-Y output requests. The plotter selection card is described as item 1 in Section 4.3.2.1.

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If the output is limited to printing and/or punching the plotter selection card is not required. The command operation card is used to request the various forms of X-Y output. This card is described in Section 4.3.3.

If only the required cards are used, the graphic control items will all assume default values. Curves using all default parameters have the following general characteristics:

1. Tic marks are drawn on all edges of the frame. Five spaces are provided on each edge of the frame.
2. All tic marks are labeled with their values.
3. Linear scales are used.
4. Scales are selected such that all points fall within the frame.
5. The plotted points are connected with straight lines.
6. The plotted points are not identified with symbols.

The above characteristics may be modified by inserting any of the parameter definition cards, described in Section 4.3.2, ahead of the command operation card or cards. The use of a parameter definition card sets the value of that parameter for all following command operation cards unless the CLEAR card is inserted (see item 16 of Section 4.3.2.1). If grid lines are requested, they will be drawn at the locations of all tic marks that result from defaults or user request. The locations of tic marks (or grid lines) for logarithmic scales cannot be selected by the user. Default values for logarithmic spacing are selected by the program. The default values for the number of tic marks (or grid lines) per cycle depend on the number of logarithmic cycles required for the range of the plotted values.

The definition and rules for the X-Y output request packet cards follow. The definition notation used in Section 4.2.1.2 will also be followed here. The form of statements used in the X-Y output request packet differs in many instances from that of similar cards used in the structure plotter request packet. The user is cautioned to prepare his input decks as specified herein.

X-Y OUTPUT

4.3.2 Parameter Definition Cards

4.3.2.1 Cards Pertaining to All Curves

1. PLOTTER = plotter name, model name

Selects plotter; required if plots are requested. Plotter choices are listed in Section 4.1. (Note: one or both of the plot tapes must be set up. See Section 5 of the Programmer's Manual for instructions.)

2. CAMERA = c (Integer)

Used for microfilm plotters only to select camera as follows: $c \leq 1$ for film, $c = 2$ for paper, $c \geq 3$ for both; default value is 3.

3. PENSIZE = ps (Integer ≥ 0)

Used to select pen for table plotter; default value is 1. (See Section 4.2.2.2)

4. DENSITY = d (Integer ≥ 0)

Used to select line density for microfilm plotters only; default value is 1. A line density of d is d times heavier than a line density of 1.

5. SKIP = s (Integer ≥ 0)

Used to insert blank frames between requested frames for microfilm plotters; default value is 1.

6. XPAPER = x (Real)
YPAPER = y (Real)

Defines paper size for table plotters; default value is $x = 8.5$ inches and $y = 11.0$ inches.

7. XMIN = x1 (Real)
XMAX = x2 (Real)

Specifies limits of abscissa of curve; default values are chosen so as to accommodate all points.

8. XLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for logarithmic x-coordinate, default value is NØ. Default value for tic division interval depends on number of log cycles (see table at end of this Section).

9. YAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for plotting y-axis; default value is NØ.

10. XINTERCEPT = xi (Real)

Location on the x-axis where the y-axis will be drawn; default value is 0.0.

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11. UPPER TICS = ut (Integer*)

Request for tick marks to be drawn on the upper edge of the frame; default value is integer one.

12. LOWER TICS = lt (Integer*)

Request for tic marks to be drawn on the lower edge of the frame; default value is integer one.

13. CURVELINESYMBOL = cls (Integer)

Request for points to be connected by lines (cls = 0), identified by symbol |cls| (cls < 0), or both (cls > 0); default value is 0; see Section 4.2.2.3 for the list of symbols. If cls ≠ 0, subsequent curves on the same frame will cause cls to be incremented by one (decrement by one if cls < 0) for each curve and thus cycle through the available symbols.

14. XDIVISIONS = xd (Integer > 0)

Applies xd uniform spaces along the x-direction for whichever of the following are called for: UPPER TICS, LOWER TICS, YINTERCEPT; default value is 5 spaces, not applicable to log scales.

15. XVALUE PRINT SKIP = xps (Integer ≥ 0)

Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is xps.

16. CLEAR

Causes all parameter values except PLOTTER and titles (XTITLE, YTITLE, YTTITLE, YBTITLE, TCURVE) to revert to their default values.

17. XTITLE = {any legitimate character string}

Title to be used with x-axis.

18. TCURVE = {any legitimate character string}

Curve title.

The default values for tic divisions on log plots are given in the following table, but will range over whole cycles:

Number of Cycles	Intermediate Values
1, 2	2., 3., 4., 5., 6., 7., 8., 9.
3	2., 3., 5., 7., 9.
4	2., 4., 6., 8.
5	2., 5., 8.
6, 7	3., 6.
8, 9, 10	3.

4.3.2.2 Cards Pertaining Only to Whole Frame Curves

1. YMIN = y1 (Real)
YMAX = y2 (Real)

Specifies limits of ordinate of curve; default values are chosen so as to accommodate all points.

*See note on page 4.3-8.

X-Y OUTPUT

2. XAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for plotting x-axis; default value is NØ.

3. YINTERCEPT = yi (Real)

Location on the y-axis where x-axis is drawn; default value is 0.0.

4. YLOG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for logarithmic y-coordinate; default value is NØ. Default value for tic division interval depends on number of log cycles (see Section 4.3.2.1).

5. LEFT TICS = lt (Integer*)

Request for tic marks to be drawn on the left edge of the frame; default value is integer one.

6. RIGHT TICS = rt (Integer*)

Request for tic marks to be drawn on the right edge of the frame; default value is integer one.

7. ALLEDGE TICS = aet (Integer*)

Request for tic marks to be drawn on all edges of the frame; default value is zero.

8. YDIVISIONS = yd (Integer > 0)

y-division tic divisions; default value is 5 spaces; not applicable to log scales.

9. YVALUE PRINT SKIP = yps (Integer \geq 0)

Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is yps.

10. XGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

11. YGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

12. YTITLE = {any legitimate character string}

Title to be used with y-axis.

4.3.2.3 Cards Pertaining Only to Upper Half Frame Curves

1. YTMIN = yt1 (Real)
YTMAX = yt2 (Real)

Specifies limits of ordinate of curve; default values are chosen so as to accomodate all points.

*See note on page 4.3-8.

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2. XTAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$
Request for plotting x-axis; default value is NØ.
3. YTINTERCEPT = yti (Real)
Location on the y-axis where x-axis is drawn; default value if 0.0.
4. YTLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$
Request for logarithmic y-coordinate, default value is NØ. Default value for tic division interval depends on number of log cycles (see table in Section 4.3.2.1).
5. TLEFT TICS = tlt (Integer*)
Request for tic marks to be drawn on the left edge of the upper half frame; default value is integer one.
6. TRIGHT TICS = trt (Integer*)
Request for tic marks to be drawn on the right edge of the upper half frame; default value is integer one.
7. TALL EDGE TICS = taet (Integer*)
Request for tic marks to be drawn on all edges of the upper half frame; default value is zero.
8. YTDIVISIØNS = ytd (Integer > 0)
y-division tic divisions; default value is 5 spaces; not applicable to log scales.
9. YTVALUE PRINT SKIP = ytps (Integer \geq 0)
Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is ytps.
10. XTGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$
Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.
11. YTGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$
Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.
12. YTTITLE = {any legitimate character string}
Title to be used with y-axis.

*See note on page 4.3-8.

X-Y OUTPUT

4.3.2.4 Cards Pertaining Only to Lower Half Frame Curves

1. YBMIN = yb1 (Real)
YBMAX = yb2 (Real)

Specifies limits of ordinate of curve; default values are chosen so as to accommodate all points.

2. XBAXIS = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for plotting x-axis; default value is NØ.

3. YBINTERCEPT = ybi (Real)

Location on the y-axis where x-axis is drawn; default value is 0.0.

4. YBLØG = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for logarithmic y-coordinate; default value is NØ; default value for tic division interval depends on number of log cycles (see table in Section 4.3.2.1).

5. BLEFT TICS = blt (Integer*)

Request for tic marks to be drawn on the left edge of the lower half frame; default value is integer one.

6. BRIGHT TICS = brt (Integer*)

Request for tic marks to be drawn on the right edge of the lower half frame; default value is integer one.

7. BALL EDGE TICS = baet (Integer*)

Request for tic marks to be drawn on all edges of the lower half frame; default value is zero.

8. YBDIVISIONS = ybd (Integer > 0)

y-direction tic divisions; default value is 5 spaces; not applicable to log scales.

9. YBVALUE PRINT SKIP = ybps (Integer ≥ 0)

Request for values to be placed on tic marks. The number of tic marks to be skipped between labeled tic marks is ybps.

10. XBGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

* See note on page 4.3-8.

PLOTTING

11. YBGRID LINES = $\begin{Bmatrix} \text{YES} \\ \text{NØ} \end{Bmatrix}$

Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

12. YBTITLE = any legitimate character string

Title to be used with y-axis.

* Note

To determine if on any given edge (a) tic marks will be drawn without values, (b) no tic marks or values will be drawn or (c) tic marks with values will be drawn, the following sum must be computed by the user. Add the tic integer value of the edge in question to its associated ALLEDGE TICS, TALL EDGE TICS, or BALL EDGE TICS integer value. If the resulting value is less than 0, tic marks will be drawn without values. If the resulting value is 0, no tic marks or values will be drawn. If the resulting value is greater than 0, tic marks with values will be drawn. The user should be "careful" in his use of the ALLEDGE TICS, TALL EDGE TICS, or BALL EDGE TICS cards. For example, the use of only the ALLEDGE TICS = -1 card will result in no tic marks or values being drawn since the default values for individual edges is + 1. Tic values input may only be -1, 0, or 1.

X-Y OUTPUT

4.3.3 Command Operation Cards

When a command operation is encountered, one or more frames will be generated using the current parameter specifications. The form of this card is:

Operation 1 or more (required)	Curve Type 1 only (required)	Plot Type	Subcase List	Curve Request(s)
$\left\{ \begin{array}{l} \text{XYPLØT} \\ \text{XYPRINT} \\ \text{XYPUNCH} \\ \text{XYPEAK} \\ \text{XYPAPLØT} \end{array} \right\}$	$\left\{ \begin{array}{l} \text{ACCE} \\ \text{DISP} \\ \text{ELFØRCE} \\ \text{NØNLINER} \\ \text{ØLØAD} \\ \text{SACCE} \\ \text{SDISP} \\ \text{SPCF} \\ \text{STRESS} \\ \text{SVELØ} \\ \text{VECTØR} \\ \text{VELØ} \\ \text{VG} \end{array} \right\}$	$\left\{ \begin{array}{l} \text{RESPØNSE} \\ \text{AUTØ} \\ \text{PSDF} \end{array} \right\}$ NA	$\left\{ \begin{array}{l} i_1, i_2, i_3, \\ i_4 \text{ THRU } i_5, \\ i_6, \text{ etc.} \end{array} \right\}$ default is all subcases NA	"frames"

Operation - The entries in the Operation field have the following meaning:

1. XYPLØT - generate X-Y plots for the selected plotter.
2. XYPRINT - generate tabular printer output for the X-Y pairs.
3. XYPUNCH - generate punched card output for the X-Y pairs. Each card contains the following information:
 1. X-Y pair sequence number
 2. X-value
 3. Y-value
 4. Card sequence number
4. XYPEAK - output is limited to the printed summary page for each curve. This summary page contains the maximum and minimum values of y for the range of x.
5. XYPAPLØT - generate X-Y plots on the printer. When the paper is rotated 90° for viewing the paper plots, the X axis moves horizontally along the page and the Y axis moves vertically along the page. Symbol '*' identifies the points associated with the first curve of a frame, then for successive curves on the frame the points are designated by symbols 'O', 'A', 'B', 'C', 'D', 'E', 'F', 'G' and 'H'.

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Curve Type - The entries in the curve type field have the meaning given below. Only one may appear in a single command operation logical card. However, there is no limit to the number of such cards.

<u>Curve Type</u>	<u>Meaning</u>
ACCE	Acceleration in the physical set
DISP	Displacement in the physical set
ELFØRCE	Element Force
NØNLINER	Nonlinear load
ØLØAD	Load
SACCE	Acceleration in the solution set
SDISP	Displacement in the solution set
SPCF	Single-point force of constraint
STRESS	Element stress
SVELØ	Velocity in the solution set
VECTØR	Displacement in the physical set
VELØ	Velocity in the physical set
VG	Flutter Analysis Curves

Solution set requests are more efficient, as the time-consuming recovery of the dependent displacements can be avoided. If there is a request for STRESS or ELFØRCE, the recovery of dependent displacements cannot be avoided.

Plot Type - The entries in the Plot Type field have the following meanings:

1. RESPØNSE - generate output for static analysis, frequency response, or transient response. This is the default value.
2. AUTØ - generate output for the autocorrelation function.
3. PSDF - generate output for the power spectral density function.

Subcase List - Generate output for the subcase numbers that are listed. Default is all subcases for which solutions were obtained. The subcase list must be in ascending order.

Curve Request(s) - The word "frames" represents a series of curve identifiers of the following general form:

/a1(b1,c1),a2(b2,c2),etc./d1(e1,f1),d2(e2,f2),etc./etc.

The information between slashes (/) specifies curves that are to be drawn on the same frame. The symbol a1 identifies the grid point or element number associated with the first plot on the first frame. The symbol a2 identifies the grid point or element number associated with the second plot on the first frame. The symbols d1 and d2 identify similar items for plots on the second frame, etc. Symbols are assigned in order by grid point or element identification number.

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The symbols b1 and b2 are codes for the items to be plotted on the upper half of the first frame, and c1 and c2 are codes for the items to be plotted on the lower half of the first frame. If any of the symbols b1, c1, b2, or c2 are missing, the corresponding curve is not generated. If the comma (,) and c1 are absent along with the comma (,) and c2, full frame plots will be prepared on the first frame for the items represented by b1 and b2. For any single frame, curve identifiers must be all of the whole frame type or all of the half frame type, i.e., the comma (,) following b1 and b2 must be present for all entries or absent for all entries in a single frame. The symbols e1, f1, e2, and f2 serve a similar purpose for the second frame, etc. If continuation cards are needed the previous card may be terminated with any one of the slashes (/) or commas (,) in the general format.

The manner in which the item code (e.g., b1, b2) is implemented is dependent upon whether the Plot Type is either (a) RESPONSE or (b) AUTO or PSDF.

For VG plots, the a1, a2 refers to the loop count of flutter analysis. The quantities b and c may have the values F for frequency and G for damping.

Plot Type RESPONSE

For geometric grid points, the item code is one of the mnemonics T1, T2, T3, R1, R2, R3, T1RM, T2RM, T3RM, R1RM, R2RM, R3RM, T1IP, T3IP, R1IP, R2IP, or R3IP, where Ti stands for the ith translational component, Ri stands for the ith rotational component, and RM means real or magnitude and IP means imaginary or phase. For scalar or extra points, use T1, T1RM, or T1IP. For elements use a positive integer from the following tables for element stress item codes or element force item codes. See Section 1.3 for interpretation of symbols.

Plot Types AUTO or PSDF

For geometric grid points, the item code is one of the mnemonics T1, T2, T3, R1, R2, R3; for scalar or extra points use T1. The symbols T1, T2, T3, R1, R2, R3 are defined as above. For elements use a positive integer from the following tables noting that if an item has a real and imaginary part, the selection of either part will result in the use of both parts. Real numbers will be treated as if they are complex numbers with zero imaginary parts. Split frames cannot be used for AUTO or PSDF plots.

PLOTTING

Element Stress Item Codes

(All items are stresses unless otherwise denoted)

Element Name	Real Element Stresses		Complex Element Stresses		Real-Mag. or Imag.-Phase
	Item Code	Item	Item Code	Item	
RØD	2	Axial Stress	2	Axial Stress	RM
	3	Axial Safety Margin	3	Axial Stress	IP
	4	Torsional Stress	4	Torsional Stress	RM
	5	Torsional Safety Margin	5	Torsional Stress	IP
TUBE		Same as RØD		Same as RØD	
SHEAR	2	Maximum Shear	2	Maximum Shear	RM
	3	Average Shear	3	Maximum Shear	IP
	4	Safety Margin	4	Average Shear	RM
			5	Average Shear	IP
TWIST	2	Maximum	2	Maximum	RM
	3	Average	3	Maximum	IP
	4	Safety Margin	4	Average	RM
			5	Average	IP
TRIA1		Z1 = Fibre Distance 1		Z1 = Fibre Distance 1	
	3	Normal-x at Z1	3	Normal-x at 1	RM
	4	Normal-y at Z1	4	Normal-x at 1	IP
	5	Shear-xy at Z1	5	Normal-y at 1	RM
	6	θ-Shear Angle at Z1	6	Normal-y at 1	IP
	7	Major-Principal at Z1	7	Shear-xy at 1	RM
	8	Minor-Principal at Z1	8	Shear-xy at 1	IP
	9	Max-Shear at Z1		Z2 = Fibre Distance 2	
		Z2 = Fibre Distance 2	10	Normal-x at 2	RM
	11	Normal-x at Z2	11	Normal-x at 2	IP
	12	Normal-y at Z2	12	Normal-y at 2	RM
	13	Shear-xy at Z2	13	Normal-y at 2	IP
	14	θ-Shear Angle at Z2	14	Shear-xy at 2	RM
	15	Major-Principal at Z2	15	Shear-xy at 2	IP
	16	Minor-Principal at Z2			
	17	Maximum-Shear at Z2			
TRBSC		Same as TRIA1		Same as TRIA1	
TRPLT		Same as TRIA1		Same as TRIA1	
TRMEM	2	Normal-x	2	Normal-x	RM
	3	Normal-y	3	Normal-x	IP
	4	Shear-xy	4	Normal-y	RM
	5	θ-Shear Angle	5	Normal-y	IP
	6	Major-Principal	6	Shear-xy	RM
	7	Minor-Principal	7	Shear-xy	IP
	8	Maximum Shear			
CØNRØD		Same as RØD		Same as RØD	
ELAS1	2	Stress	2	Stress	RM
			3	Stress	IP
ELAS2	2	Stress	2	Stress	RM
			3	Stress	IP

X-Y OUTPUT

Element		Real Element Stresses		Complex Element Stresses		Real-Mag. or Imag.-Phase
Name	Item Code	Item		Item Code	Item	
ELAS3	2	Stress		2	Stress	RM
				3	Stress	IP
QDPLT		Same as TRIA1		Same as TRIA1		
QDMEM		Same as TRMEM		Same as TRMEM		
QDMEM1		Same as TRMEM		Same as TRMEM		
QDMEM2		Same as TRMEM		Same as TRMEM		
TRIA2		Same as TRIA1		Same as TRIA1		
QUAD2		Same as TRIA1		Same as TRIA1		
QUAD1		Same as TRIA1		Same as TRIA1		
BAR	2	SA1	}	2	SA1	RM
	3	SA2		3	SA2	RM
	4	SA3		4	SA3	RM
	5	SA4		5	SA4	RM
	6	Axial		6	Axial	RM
	7	SA-maximum		7	SA1	IP
	8	SA-minimum		8	SA2	IP
	9	Safety Margin in Tension		9	SA3	IP
	10	SB1	}	10	SA4	IP
	11	SB2		11	Axial	IP
	12	SB3		12	SB1	RM
	13	SB4		13	SB2	RM
	14	SB-maximum		14	SB3	RM
	15	SB-minimum		15	SB4	RM
	16	Safety Margin in Comp.		16	SB1	IP
				17	SB2	IP
				18	SB3	IP
				19	SB4	IP
CONEAX		Z1 = Fibre Distance 1				
	4	Normal-u	at 1			
	5	Normal-v	at 1			
	6	Shear-uv	at 1			
	7	θ-Shear Angle	at 1			
	8	Major-Principal	at 1			
	9	Minor-Principal	at 1			
	10	Maximum Shear	at 1			
		Z2 = Fibre Distance 2				
	12	Normal-u	at 2			
	13	Normal-v	at 2			
	14	Shear-uv	at 2			
	15	θ-Shear Angle	at 2			
	16	Major-Principal	at 2			
	17	Minor-Principal	at 2			
	18	Maximum Shear	at 2			
TRIARG	2	Radial (x)				
	3	Circum. (Theta)				
	4	Axial (z)				
	5	Shear (zx)				

*See footnote 2 on next page.

PLOTING

Element Name	Real Element Stresses			Complex Element Stresses		
	Item Code	Item		Item Code	Item	Real-Mag. or Imag.-Phase
TRAPRG	2	Radial (x)	at 1			
	3	Circum. (Theta)	at 1			
	4	Axial (z)	at 1			
	5	Shear (zx)	at 1			
	6	Radial (x)	at 2			
	7	Circum. (Theta)	at 2			
	8	Axial (z)	at 2			
	9	Shear (zx)	at 2			
	10	Radial (x)	at 3			
	11	Circum. (Theta)	at 3			
	12	Axial (z)	at 3			
	13	Shear (zx)	at 3			
	14	Radial (x)	at 4			
	15	Circum. (Theta)	at 4			
	16	Axial (z)	at 4			
	17	Shear (zx)	at 4			
	18	Radial (x)	at 5			
	19	Circum. (Theta)	at 5			
	20	Axial (z)	at 5			
	21	Shear (zx)	at 5			
TØRDRG	2	Mem.-Tangen.	at 1			
	3	Mem.-Circum.	at 1			
	4	Flex.-Tangen.	at 1			
	5	Flex.-Circum.	at 1			
	6	Shear-Force	at 1			
	7	Mem.-Tangen.	at 2			
	8	Mem.-Circum.	at 2			
	9	Flex.-Tangen.	at 2			
	10	Flex.-Circum.	at 2			
	11	Shear-Force	at 2			
	12	Mem.-Tangen.	at 3			
	13	Mem.-Circum.	at 3			
	14	Flex.-Tangen.	at 3			
	15	Flex.-Circum.	at 3			
	16	Shear-Force	at 3			
TETRA	2	Normal (x)		2	Normal (x)	RM
	3	Normal (y)		3	Normal (y)	RM
	4	Normal (z)		4	Normal (z)	RM
	5	Shear (yz)		5	Shear (yz)	RM
	6	Shear (xy)		6	Shear (xy)	RM
	7	Shear (xz)		7	Shear (xz)	RM
	8	Octahedral		8	Normal (x)	IP
	9	Pressure		9	Normal (y)	IP
				10	Normal (z)	IP
				11	Shear (yz)	IP
				12	Shear (xy)	IP
				13	Shear (xz)	IP
WEDGE	Same as TETRA			Same as TETRA		
HEXA1	Same as TETRA			Same as TETRA		
HEXA2	Same as TETRA			Same as TETRA		

X-Y OUTPUT

Element Name	Real Element Stresses		Complex Element Stresses		Real-Mag. or Imag.-Phase
	Item Code	Item	Item Code	Item	
AXIF2	2	Radial-Axis	2	Radial-Axis	RM
	3	Axial-Axis	3	Axial-Axis	RM
	4	Tangential-Edge	4	Tangential-Edge	RM
	5	Circumferential-Edge	5	Circumferential-Edge	RM
			6	Radial-Axis	IP
			7	Axial-Axis	IP
			8	Tangential-Edge	IP
			9	Circumferential-Edge	IP
AXIF3	2	Radial-centroid	2	Radial-centroid	RM
	3	Circumferential-centroid	3	Circumferential-centroid	RM
	4	Axial-centroid	4	Axial-centroid	RM
	5	Tangential-edge 1	5	Tangential-edge 1	RM
	6	Circumferential-edge 1	6	Circumferential-edge 1	RM
	7	Tangential-edge 2	7	Tangential-edge 2	RM
	8	Circumferential-edge 2	8	Circumferential-edge 2	RM
	9	Tangential-edge 3	9	Tangential-edge 3	RM
	10	Circumferential-edge 3	10	Circumferential-edge 3	RM
			11	Radial-centroid	IP
			12	Circumferential-centroid	IP
			13	Axial-centroid	IP
			14	Tangential-edge 1	IP
			15	Circumferential-edge 1	IP
			16	Tangential-edge 2	IP
			17	Circumferential-edge 2	IP
			18	Tangential-edge 3	IP
			19	Circumferential-edge 3	IP
AXIF4	2	Radial-centroid	2	Radial-centroid	RM
	3	Circumferential-centroid	3	Circumferential-centroid	RM
	4	Axial-centroid	4	Axial-centroid	RM
	5	Tangential-edge 1	6	Tangential-edge 1	RM
	6	Circumferential-edge 1	6	Circumferential-edge 1	RM
	7	Tangential-edge 2	7	Tangential-edge 2	RM
	8	Circumferential-edge 2	8	Circumferential-edge 2	RM
	9	Tangential-edge 3	9	Tangential-edge 3	RM
	10	Circumferential-edge 3	10	Circumferential-edge 3	RM
	11	Tangential-edge 4	11	Tangential-edge 4	RM
	12	Circumferential-edge 4	12	Circumferential-edge 4	RM
			13	Radial-centroid	IP
			14	Circumferential-centroid	IP
			15	Axial-centroid	IP
			16	Tangential-edge 1	IP
			17	Circumferential-edge 1	IP
			18	Tangential-edge 2	IP
			19	Circumferential-edge 2	IP
			20	Tangential-edge 3	IP
			21	Circumferential-edge 3	IP
			22	Tangential-edge 4	IP
			23	Circumferential-edge 4	IP

PLOTING

Element Name	Real Element Stresses		Complex Element Stresses		Real-Mag. or Imag.-Phase
	Item Code	Item	Item Code	Item	
SLØT3	2	Radial-centroid	2	Radial-centroid	RM
	3	Axial-centroid	3	Axial-centroid	RM
	4	Tangential-edge 1	4	Tangential-edge 1	RM
	5	Tangential-edge 2	5	Tangential-edge 2	RM
	6	Tangential-edge 3	6	Tangential-edge 3	RM
			7	Radial-centroid	IP
			8	Axial-centroid	IP
			9	Tangential-edge 1	IP
			10	Tangential-edge 2	IP
			11	Tangential-edge 3	IP
SLØT4	2	Radial-centroid	2	Radial-centroid	RM
	3	Axial-centroid	3	Axial-centroid	RM
	4	Tangential-edge 1	4	Tangential-edge 1	RM
	5	Tangential-edge 2	5	Tangential-edge 2	RM
	6	Tangential-edge 3	6	Tangential-edge 3	RM
	7	Tangential-edge 4	7	Tangential-edge 4	RM
			8	Radial-centroid	IP
			9	Axial-centroid	IP
			10	Tangential-edge 1	IP
			11	Tangential-edge 2	IP
			12	Tangential-edge 3	IP
			13	Tangential-edge 4	IP
CIHEX1*	2	External grid point ID	2	External grid point ID	
	3	Normal - x	3	Normal - x	RM
	4	Shear - xy	4	Normal - y	RM
	5	First principal	5	Normal - z	RM
	6	First principal x cosine	6	Shear - xy	RM
	7	Second principal x cosine	7	Shear - yz	RM
	8	Third principal x cosine	8	Shear - zx	RM
	9	Mean stress	9	Normal - x	IP
	10	Octahedral shear stress	10	Normal - y	IP
	11	Normal - y	11	Normal - z	IP
	12	Shear - yz	12	Shear - xy	IP
	13	Second principal	13	Shear - yz	IP
	14	First principal y cosine	14	Shear - zx	IP
	15	Second principal y cosine			
	16	Third principal y cosine			
	17	Normal - z			
	18	Shear - zx			
	19	Third principal			
	20	First principal z cosine			
	21	Second principal z cosine			
	22	Third principal z cosine			
CIHEX2*	Same as CIHEX1		Same as CIHEX1		
CIHEX3*	2	First external grid point ID	2	First external grid point ID	
	3	Normal - x	3	Normal - x	RM
	4	Shear - xy	4	Normal - y	RM
	5	First principal	5	Normal - z	RM
	6	First principal x cosine	6	Shear - xy	RM

X-Y OUTPUT

Element Name	Real Element Stresses		Complex Element Stresses		Real-Mag. or Imag.-Phase
	Item Code	Item	Item Code	Item	
	7	Second principal x cosine	7	Shear - yz	RM
	8	Third principal x cosine	8	Shear - zx	RM
	9	Mean stress	9	Second external grid point ID	
	10	Octahedral shear stress	10	Normal - x	IP
	11	Second external grid point ID	11	Normal - y	IP
	12	Normal - y	12	Normal - z	IP
	13	Shear - yz	13	Shear - xy	IP
	14	Second principal	14	Shear - yz	IP
	15	First principal y cosine	15	Shear - zx	IP
	16	Second principal y cosine			
	17	Third principal y cosine			
	18	Normal - z			
	19	Shear - zx			
	20	Third principal			
	21	First principal z cosine			
	22	Second principal z cosine			
	23	Third principal z cosine			
TRAPAX	2	Harmonic or Point Angle			
	3	Radial (R)			
	4	Axial (Z)			
	5	Circum (Theta-T)			
	6	Shear (ZR)			
	7	Shear (RT)			
	8	Shear (ZT)			
TRIAAX	2	Harmonic or Point Angle			
	3	Radial (R)			
	4	Axial (Z)			
	5	Circum (Theta-T)			
	6	Shear (ZR)			
	7	Shear (RT)			
	8	Shear (ZT)			

*The stresses are repeated for each stress point within each element.

Note:

1. If output is magnitude/phase the magnitude replaces the real part and the phase replaces the imaginary part.

2. The symbols SA1,2,3,4 and SB1,2,3,4 stand for stresses on end A or B at locations C, D, E, and F respectively as defined on the first continuation card of the PBAR bulk data card.

X-Y OUTPUT

Element Force Item Codes

(All items are element forces (or moments) unless otherwise indicated)

Element Name	Real Element Forces		Complex Element Forces		Real-Mag. or Imag.-Phase
	Item Code	Item	Item Code	Item	
RØD	2	Axial Force	2	Axial Force	RM
	3	Torque	3	Axial Force	IP
			4	Torque	RM
			5	Torque	IP
TUBE		Same as RØD		Same as RØD	
SHEAR	2	Force Pts. 1, 3	2	Force Pts. 1, 3	RM
	3	Force Pts. 2, 4	3	Force Pts. 1, 3	IP
			4	Force Pts. 2, 4	RM
			5	Force Pts. 2, 4	IP
TWIST	2	Moment Pts. 1, 3	2	Moment Pts. 1, 3	RM
	3	Moment Pts. 2, 4	3	Moment Pts. 1, 3	IP
			4	Moment Pts. 2, 4	RM
			5	Moment Pts. 2, 4	IP
TRIA1	2	Bend-Moment-x	2	Bend-Moment-x	RM
	3	Bend-Moment-y	3	Bend-Moment-y	RM
	4	Twist-Moment	4	Twist-Moment	RM
	5	Shear-x	5	Shear-x	RM
	6	Shear-y	6	Shear-y	RM
			7	Bend-Moment-x	IP
			8	Bend-Moment-y	IP
			9	Twist-Moment	IP
			10	Shear-x	IP
			11	Shear-y	IP
TRBSC		Same as TRIA1		Same as TRIA1	
TRPLT		Same as TRIA1		Same as TRIA1	
CØNRØD		Same as RØD		Same as RØD	
ELAS1	2	Force	2	Force	RM
			3	Force	IP
ELAS2	2	Force	2	Force	RM
			3	Force	IP
ELAS3	2	Force	2	Force	RM
			3	Force	IP
ELAS4	2	Force	2	Force	RM
			3	Force	IP
QDPLT		Same as TRIA1		Same as TRIA1	
TRIA2		Same as TRIA1		Same as TRIA1	
QUAD2		Same as TRIA1		Same as TRIA1	

PLOTTING

Element Name	Real Element Forces			Complex Element Forces			Real-Mag. or Imag.-Phase
	Item Code	Item		Item Code	Item		
QUAD1		Same as TRIA1			Same as TRIA1		
BAR	2	Bend-Moment	A1	2	Bend-Moment	A1	RM
	3	Bend-Moment	A2	3	Bend-Moment	A2	RM
	4	Bend-Moment	B1	4	Bend-Moment	B1	RM
	5	Bend-Moment	B2	5	Bend-Moment	B2	RM
	6	Shear-1		6	Shear-1		RM
	7	Shear-2		7	Shear-2		RM
	8	Axial Force		8	Axial Force		RM
	9	Torque		9	Torque		RM
				10	Bend-Moment	A1	IP
				11	Bend-Moment	A2	IP
				12	Bend-Moment	B1	IP
				13	Bend-Moment	B2	IP
				14	Shear-1		IP
				15	Shear-2		IP
				16	Axial Force		IP
				17	Torque		IP
	CQDMEM2	2	Force	4 to 1			
3		Force	2 to 1				
4		Force	1 to 2				
5		Force	3 to 2				
6		Force	2 to 3				
7		Force	4 to 3				
8		Force	3 to 4				
9		Force	1 to 4				
10		Kick Force	on 1				
11		Shear-12					
12		Kick Force	on 2				
13		Shear-23					
14		Kick Force	on 3				
15		Shear-34					
16		Kick Force	on 4				
17		Shear-41					
TRAPAX		2	Harmonic or Point Angle				
	3	Radial (R)	at 1				
	4	Circum (Theta-T)	at 1				
	5	Axial (Z)	at 1				
	6	Radial (R)	at 2				
	7	Circum (Theta-T)	at 2				
	8	Axial (Z)	at 2				
	9	Radial (R)	at 3				
	10	Circum (Theta-T)	at 3				
	11	Axial (Z)	at 3				
	12	Radial (R)	at 4				
	13	Circum (Theta-T)	at 4				
	14	Axial (Z)	at 4				

X-Y OUTPUT

Element Name	Real Element Forces		Complex Element Forces		Real-Mag. or Imag.-Phase
	Item Code	Item	Item Code	Item	
TRIAAX	2	Harmonic or Point Angle			
	3	Radial (R) at 1			
	4	Circum (Theta-T) at 1			
	5	Axial (Z) at 1			
	6	Radial (R) at 2			
	7	Circum (Theta-T) at 2			
	8	Axial (Z) at 2			
	9	Radial (R) at 3			
	10	Circum (Theta-T) at 3			
	11	Axial (Z) at 3			

X-Y OUTPUT

4.3.4 Examples of X-Y Output Request Packets

BEGIN BULK or OUTPUT(PLØT) card is shown as a reminder to the user to place his X-Y output request packet properly in his Case Control Deck, i.e., at the end of the Case Control Deck or just ahead of any structure plot requests.

Example 1

```
ØUTPUT(XYPLØT)
PLØTTER = SC 4020
XYPLØT SDISP / 16(T1)
BEGIN BULK
```

Causes a single whole frame to be plotted for the T1 displacement component of solution set point 16 using the default parameter values. If 16(T1) is not in the solution set, a warning message will be printed and no plot will be made. The plot will be generated for the SC 4020 plotter on NASTRAN tape PLT2 which must be set up.

Example 2

```
ØUTPUT(XYØUT)
PLØTTER =EAI 3500
XYPLØT, XYPRINT VELØ RESPØNSE 1,5 / 3(R1, ), 5( ,R1)
ØUTPUT(PLØT)
```

Causes a single frame (consisting of an upper half frame and a lower half frame) to be plotted using the default parameter values. The velocity of the first rotational component of grid point 3 will be plotted on the upper half frame and that of grid point 5 will be plotted on the lower half frame for subcases 1 and 5. Tabular printer output will also be generated for both curves. The plots will be generated for the EAI 3500, 30-inch, table plotter on NASTRAN tape PLT1 which must be set up. Scales will be selected such that the frame will fit on 8 1/2 x 11-inch paper.

Example 3

```
ØUTPUT(XYPLØT)
PLØTTER = SC 4020
YDIVISIØNS = 20
XDIVISIØNS = 10
XGRID LINES = YES
YGRID LINES = YES
XYPLØT DISP 2,5 /10(T1),10(T3)
```

Causes two whole frame plots to be generated, one for subcase 2 and one for subcase 5. Each

PLOTTING

plot contains the T1 and T3 displacement component for grid point 10. The default parameters will be modified to include grid lines in both the x and y-directions with 10 spaces in the x-direction and 20 spaces in the y-direction. The plot will be generated for the SC 4020 plotter on NASTRAN tape PLT2 which must be set up.

Example 4

```
ØUTPUT(XYPLØT)
PLØTTER = EAI 3500
XAXIS = YES
YAXIS = YES
XPAPER = 17.0
YPAPER = 22.0
XYPLØT STRESS 3/ 15(2)/ 21(6)
```

Causes two whole frame plots to be generated using the results from subcase 3. The first plot is the response of the axial stress for rod element number 15. The second plot is the response of the major principal stress for triangular membrane element number 21. The default parameters will be modified to include the x-axis and y-axis drawn through the origin. Each plot will be scaled to fit on 17 x 22-inch paper. The plots will be generated for the EAI 3500, 30-inch, table plotter on NASTRAN tape PLT1 which must be set up.

Example 5

```
ØUTPUT (XYPLØT)
PLØTTER = NASTPLT D,0
CURVELINESYMBOL = -1
XYPLØT VG / 1(G,F) 2(G,F) 3(G,F) 4(G,F)
```

A split frame plot will be made; the upper half is V-g and the lower half is V-f. Data from the first four loops will be plotted. Distinct symbols are used for data from each loop, and no lines are drawn between points (since the flutter analyst must sometimes exercise judgement about which points should be connected).

X-Y OUTPUT

4.3.5 Summary of X-Y Output Request Packet Cards

Type of value: I = Integer, R = Real, B = BCD. See Sections 4.3.2 and 4.3.3 for details of these cards.

Items pertaining to all plots				
1.	PLØTTER	= p	-	
2.	CAMERA	= c	(I)	
3.	PENSIZE	= ps	(I)	
4.	DENSITY	= d	(I)	
5.	SKIP	= s	(I)	
6.	XPAPER	= x	(R)	
	YPAPER	= y	(R)	
7.	XMIN	= x1	(R)	
	XMAX	= x2	(R)	
8.	XLØG	= yesno*	(B)	
9.	YAXIS	= yesno*	(B)	
10.	XINTERCEPT	= xi	(R)	
11.	UPPER TICS	= ut	(I)	
12.	LØWER TICS	= lt	(I)	
13.	CURVLINESYMBOL	= cls	(I)	
14.	XDIVISIONS	= xd	(I)	
15.	XVALUE PRINT SKIP	= xps	(I)	
16.	CLEAR		-	
17.	XTITLE	= {anything}	-	
18.	TCURVE	= {anything}	-	

Whole frames only		Upper half frames only		Lower half frames only	
1	YMIN = y1	YTMIN = yt1	YBMIN = yb1	(R)	
	YMAX = y2	YTMAX = yt2	YBMAX = yb2	(R)	
2	XAXIS = yesno*	XTAXIS = yesno*	XBAXIS = yesno*	(B)	
3	YINTERCEPT = yi	YTINTERCEPT = yti	YBINTERCEPT = ybi	(I)	
4	YLØG = yesno*	YTLØG = yesno*	YBLØG = yesno*	(B)	
5	LEFT TICS = lt	TLEFT TICS = tlt	BLEFT TICS = blt	(I)	
6	RIGHT TICS = rt	TRIGHT TICS = trt	BRIGHT TICS = brt	(I)	
7	ALLEDGE TICS = aet	TALL EDGE TICS = taet	BALL EDGE TICS = baet	(I)	
8	YDIVISIONS = yd	YTDIVISIONS = ytd	YBDIVISIONS = ybd	(I)	
9	YVALUE PRINT SKIP = yps	YTVALUE PRINT SKIP = ytps	YBVALUE PRINT SKIP = ybps	(I)	
10	XGRID LINES = yesno*	XTGRID LINES = yesno*	XBGRID LINES = yesno*	(B)	
11	YGRID LINES = yesno*	YTGRID LINES = yesno*	YBGRID LINES = yesno*	(B)	
12	YTITLE = {anything}	YTTITLE = {anything}	YBTITLE = {anything}	-	

Command operation cards				
{	XYPLØT XYPRINT XYPUNCH XYPEAK XYPAPLØT	{	ACCE DISP ELFØRCE NØNLINER ØLØAD SACCE SDISP SPCF STRESS SVELØ VECTØR VELØ VG	{
{			{RESPØNSE AUTØ PSDF}	
			subcases /curves	

* yesno must be either YES or NØ

DIRECT MATRIX ABSTRACTION

5.1 GENERAL

In addition to using the rigid formats provided automatically by NASTRAN, the user may wish to execute a series of modules in a different manner than provided by the rigid format. Or, he may wish to perform a series of matrix operations which are not contained in any existing rigid format. If the modifications to an existing rigid format are minor, the ALTER feature described in Section 2 may be employed. Otherwise, a user-written Direct Matrix Abstraction Program (DMAP) should be used.

DMAP is the user-oriented language used by NASTRAN to solve problems. A rigid format is basically a collection of statements in this language. DMAP, like English or FORTRAN, has many grammatical rules which must be followed to be interpretable by the NASTRAN DMAP compiler. Section 5.2 provides the user with the rules of DMAP which will allow him to understand the rigid format DMAP sequences, write ALTER packages, and construct his own DMAP sequences using the many modules contained in the NASTRAN DMAP repertoire.

Section 5.3 is an index of matrix, utility, user and executive DMAP modules which are contained in Sections 5.4 thru 5.7 respectively.

Sections 5.4 thru 5.7 describe individually the many nonstructurally oriented modules contained in the NASTRAN library. Section 5.8 provides several examples of DMAP usage.

User-written modules must conform to the rules and usage conventions described herein.

DIRECT MATRIX ABSTRACTION

5.2 DMAP RULES

Grammatically, DMAP instructions consist of two types: Executive Operation Instructions and Functional Module Instructions. Grammatical rules for these two types of instructions will be discussed separately in subsequent sections.

Functional modules are arbitrarily classified as structural modules, matrix operation modules, utility modules, or user-generated modules.

The DMAP sequence itself consists of a series of DMAP instructions or statements, the first of which is BEGIN and the last of which is END. The remaining statements consist of Executive Operation instructions and Functional Module calls.

5.2.1 DMAP Rules for Functional Module Instructions

The primary characteristic of the Functional Module DMAP instruction is its prescribed format. The general form of the Functional Module DMAP statement is:

`MØD I1,I2,---,Im/Ø1,Ø2,---,Øn/a1,b1,p1/a2,b2,p2----/az,bz,pz $`

where MØD is the DMAP Functional Module name,
Ii; i = 1,m are the Input Data Block names,
Øi; i = 1,n are the Øutput Data Block names,
and ai,bi,pi; i = 1,z are the Parameter Sections.

In the general form shown above, commas (,) are used to separate several like items while slashes (/) are used to separate sections from one another. The module name is separated from the rest of the instruction by a blank or a comma (,). The dollar sign (\$) is used to end the instruction and is not required unless the instruction ends in the delimiter / . Blanks may be used in conjunction with any of the above delimiters for ease of reading.

A functional module communicates with other modules and the executive system entirely through its inputs, outputs and parameters. The characteristics or attributes of each functional module are contained in the Module Properties List (MPL) described in Section 2.4 of the Programmer's Manual and are reflected in the DMAP Module Descriptions that follow in Section 5.3 and in the Module Functional Descriptions contained in Chapter 4 of the Programmer's Manual. The module name is a BCD value (which consists of an alphabetic character followed by up to seven additional alphanumeric characters) and must correspond to an entry in the MPL. A Data Block name may be either a BCD value or null. The absence of a BCD value indicates that the Data Block is not needed for a particular application.

DIRECT MATRIX ABSTRACTION

5.2.1.1 Each Functional Module DMAP statement must conform to the MPL regarding

1. Name spelling
2. Number of input data blocks
3. Number of output data blocks
4. Number of parameters
5. Type of each parameter

5.2.1.2 Functional Module Names

The only Functional Module DMAP names allowed are those contained in the MPL. Therefore, if a user wishes to add a module, he must either use one of the User Module names provided (see Section 5.6 or add a name to the MPL. The Programmer's Manual should be consulted when adding a new module to NASTRAN.

5.2.1.3 Functional Module Input Data Blocks

An input data must be previously defined in the DMAP sequence. This is accomplished by causing the data block to be output from a previous DMAP instruction. Input File Processor outputs and any user-input (via Bulk Data Cards) DMI or DTI data block names are exempt from this rule as are data blocks existing on the Old Problem Tape. Since the number of Data Blocks is prescribed, the number of separating commas must be one less than the number of Data Blocks, even though one or more Data Blocks are null. An input data block may never be written on (nor have its trailer changed).

5.2.1.4 Functional Module Output Data Blocks

A data block name may appear as an output once and only once. New names may be equivalenced to old ones, however, as described in Section 5.2.3.2. Since the number of Data Blocks is prescribed, the number of separating commas must be one less than the number of Data Blocks, even though one or more Data Blocks are null.

5.2.1.5 Functional Module Parameters

Parameters are used for many purposes. They may convey data values into and/or out from the module, or they may simply serve as flags to control the computational flow within the module. The general form of a parameter section of a DMAP instruction is

ai,bi,pi

where the parameter specifications are:

DMAP RULES

$a_i = \begin{cases} V \\ C \end{cases}$	<p>Parameter value is variable and may be changed by the module during execution.</p> <p>Parameter value is prescribed initially by the user and is an unalterable constant.</p>
$b_i = \begin{cases} Y \\ N \end{cases}$	<p>Initial parameter value may be specified on a PARAM bulk data card.</p> <p>Initial parameter value may <u>not</u> be specified on a PARAM bulk data card.</p>
$p_i = \begin{cases} PNAME = v \\ PNAME \\ v \end{cases}$	<p>PNAME is a BCD value selected by the user to represent the name of the parameter.</p>

The various forms available for p_i require additional clarification. The form v means a value for the parameter and may only be used when $a_i=C$ and $b_i=N$. The other forms will be clarified in the symbolic examples that follow. Each parameter has an initial value which is established when the DMAP sequence is compiled during execution of the NASTRAN preface. The means by which initial values are established for all DMAP parameters will be explained by the symbolic examples that follow. The value used at execution time may differ from the initial value if and only if the module changes the value, if $a_i = "V"$, and the parameter name appears in a SAVE (see Section 5.7) instruction immediately following the module. Six parameter types are available. The proper type is specified by the Module Properties List (MPL). The types and examples of values as they would be written in DMAP are given below:

<u>Parameter Type</u>	<u>value Examples</u>
Integer	7 -2 0
Real	-3.6 2.4+5 0.01-3
BCD	A12
Double-Precision	2.5D0
Complex Single-Precision	(1.0,-1.0)
Complex Double-Precision	(1.9D0,-4.0D1)

Many forms of the parameter section may be used. These will be explained in some detail.

null This is equivalent to $/C,N,v$ where v is the MPL default value which must exist. No nonnull parameters may follow a null parameter in the DMAP statement. A null is not punched, nor is the preceding $/$.

$/C,N,v$ Constant input parameter
 Examples: $/C,N,0/C,N,BLK0/C,N,(1.0,-1.0)$

In the three examples shown, the values 0 (integer), BLK0 (BCD) and 1.0-i1.0 (complex, single precision) are defined.

DIRECT MATRIX ABSTRACTION

- /C,Y,PNAME Constant input parameter; MPL default value is used unless a PARAM bulk data card referencing PNAME is present. Error condition is detected if either no PARAM card is present or if no MPL default value exists.
- /C,Y,PNAME=v Constant input parameter; the value v is used unless a PARAM bulk data card referencing PNAME is present.
- /V,Y,PNAME Variable parameter; may be input, output, or both; initial value is the first of
or
1. value from the most recently executed SAVE instruction, if any
/V,Y,PNAME=v 2. value from PARAM bulk data card referencing PNAME will be used if present
in Bulk Data Deck
3. v, if present in DMAP instruction
4. MPL default value, if any
5. 0

If a parameter is output from a functional module and if the output value is to be carried forward, a SAVE instruction must immediately follow the DMAP instruction in which the parameter is generated.

- /V,N,PNAME Variable parameter; may be input, output, or both; initial value is the first of
or
1. value from the most recently executed SAVE instruction, if any
/V,N,PNAME=v 2. v, if present in DMAP instruction
3. MPL default value, if any
4. 0

5.2.2 DMAP Rules for Executive Operation Instructions

Each Executive Operation statement has its own format which is generally open-ended, meaning the number of inputs, outputs, etc. is not prescribed. Executive Operation instructions or statements are divided into general categories as follows:

1. Declarative instructions FILE, BEGIN and LABEL which aid the DMAP compiler and the file allocator.
2. Instructions CHPNT, EQUIV, PURGE and SAVE which aide the NASTRAN executive system in allocating files, interfacing between functional modules and in restarting a problem.
3. Control instructions REPT, JUMP, COND, EXIT and END which control the order in which DMAP instructions are executed.

The rules associated with the Executive Operation instructions are distinct for each instruction and are discussed individually in Section 5.7.

5.2.3 Techniques and Examples of Executive Module Usage

Even though the DMAP program may be interpretable by the DMAP compiler it does not guarantee that the program will yield the desired results. Therefore this section is provided to acquaint the DMAP programmer with techniques and examples used in writing DMAP programs. In particular the instructions REPT, FILE, EQUIV, PURGE and CHPNT will now be discussed in some detail. The DMAP module index for all nonstructural modules will be found in Section 5.3.

DMAP RULES

The new DMAP user should read Sections 5.4 through 5.7 to obtain the necessary knowledge of terminology before reading this section.

The data blocks and functional modules referenced in the following examples are fictitious and have no relationship to any real data blocks or functional modules.

A data block is described as having a status of "not generated," "generated" or "purged." A status of not generated means that the data block is available for generation by appearing as output in a functional module. A status of generated means that the data block contains data which is available for input to a subsequent module. A status of purged means that the data block cannot be generated and any functional module attempting to use this data block as input or output will be informed that the purged data block is not available for use.

5.2.3.1 The REPT and FILE Instructions (see Section 5.7)

The DMAP instructions bounded by the REPT instruction and the label referenced by the REPT instruction are referred to as a loop. The location referenced by the REPT is called the top of the loop. In many respects a DMAP loop is like a giant functional module since it requires inputs and generates output data blocks which usually can be handled correctly by the File Allocator (see Section 4.9 of the Programmer's Manual) without any special action by the DMAP programmer. The one exception is a data block that is not referenced outside the loop (i.e., an internal data block with respect to the loop). The file allocator considers internal data blocks as scratch data blocks to be used for the present pass through the loop but not to be saved for input at the top of the loop. Should the DMAP programmer desire to save an internal data block, he may do so by declaring the data block SAVE in the FILE instruction.

When the REPT instruction transfers control back to the top of the loop, the status of all internal data blocks is changed to "not generated" unless the internal data block is declared SAVE or APPEND in a FILE instruction. It should also be noted that equivalences established between internal data blocks (not declared saved) and data blocks referenced outside the loop are not carried over for the next time through the loop. The equivalence must be re-established each time through the loop. Data blocks generated by the Input File Processor are considered referenced outside of all DMAP loops.

DIRECT MATRIX ABSTRACTION

EXAMPLE using REPT and FILE instructions.

DMAP loop	{	BEGIN	\$
		FILE	X=SAVE / Y=APPEND / Z=APPEND \$
		LABEL	L1 \$
		MØD1	B/W,Y \$
		CØND	L3,PX \$
		MØD2	A/X/V,N,PX=0 \$
		SAVE	PX \$
		LABEL	L3 \$
		MØD3	W,X,Y/Z \$
		REPT	L1,1 \$
		MØD4	Z// \$
		END	\$

Assume that MØD2 sets $PX = 0$ when it is executed. Note that Z is declared APPEND, whereas Y will be saved since it is an internal data block that is to be appended. X is an internal data block that is to be saved since it will only be generated the first time through the loop but is needed as input each time the loop is repeated. W is an internal data block that is generated each time through the loop; therefore, it is not saved.

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table. Data blocks A and B are assumed to be generated by the Input File Processor, and hence are considered referenced outside of all DMAP loops.

DMAP RULES

Module being executed	Input status and comments	Output status and comments
MØD1	B-assumed generated by the input file processor	W, Y - generated
CØND	PX is 0	No transfer occurs since $PX \geq 0$
MØD2	A-assumed generated by the input file processor	X - generated PX is set < 0
SAVE	PX < 0	The value created above is saved for subsequent use.
MØD3	W, X, Y are all generated at this point	Z - generated
REPT	Loop count is initially set at 1	Transfer to L1 - set loop count to 1-1=0 Status of data blocks at top of loop will be: A, B, Z - generated (referenced outside loop) X, Y - generated (internal data blocks declared saved) W - not generated (internal data block)
MØD1	B - generated	W - generated Y - generated (appended)
CØND	PX is now < 0 due to SAVE	Transfer to L3 occurs
MØD3	W, X, Y - generated	Z - generated (appended)
REPT	Loop count is now 0	No transfer occurs.
MØD4	Z - generated	Output to printer (assumed)
END		Normal termination of problem.

5.2.3.2 The EQUIV Instruction (see Section 5.7)

There are no restrictions on the status of data blocks referenced in an EQUIV instruction. Consider the instruction EQUIV A,B₁,---,B_N/P \$ when $P < 0$. Data blocks B₁,---,B_N take on all the characteristics of data block A including the status of A. This means the status of some B_j can change from purged to generated or not generated.

The EQUIV instruction will unequivalence data blocks when $P \geq 0$. In an unequivalence operation, the status of all secondary data blocks reverts to not generated.

Suppose A, B, and C are all equivalenced and $P \geq 0$. EQUIV A,B/P \$ will break the equivalence between A and B but not between A and C.

DIRECT MATRIX ABSTRACTION

Now consider the following situation. Data block B is to be generated by repeatedly executing functional module MØD2. The input to MØD2 is the previous output from MØD2. That is to say, each successive generation of B depends on the previous B generated. The following example shows how the EQUIV instruction is used to solve this problem. Assume parameter $BREAK \geq 0$ and parameter $LINK < 0$.

EXAMPLE of EQUIV instruction.

```

      BEGIN      $
      MØD1      A/B $
      LABEL     L1 $
      EQUIV     B,BB/BREAK $
      MØD2      B/BB $
      EQUIV     BB,B/LINK $
      REPT      L1,1 $
      MØD3      BB// $
      END       $
  
```

DMAP loop {

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table.

Module being executed	Input status and comments	Output status and comments
MØD1	A-assumed generated by input processor	B - generated
EQUIV	B will not be equivalenced to BB since $BREAK \geq 0$.	No action taken.
MØD2	B-generated	BB - generated
EQUIV	BB and B are not equivalenced. B - generated BB - generated $LINK < 0$.	B is equivalenced to BB. That is, B assumes all of the characteristics of BB. B and BB then both have the status of generated.
REPT	Loop count is initially 1	Transfer to L1; set loop count to $1-1=0$.
EQUIV	B and BB are generated and equivalenced. $BREAK \geq 0$.	The equivalence is broken; B - generated, BB - not generated
MØD2	B-generated	BB - generated
EQUIV	BB and B are generated and not equivalenced. $LINK < 0$.	B equivalenced to BB; B,BB - generated
REPT	Loop count is 0	No transfer occurs.
MØD3	BB - generated	Output to printer (assumed)
END		Normal termination of problem.

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Since equivalences are automatically broken between internal files (not declared saved) and files referenced outside the loop, the above DMAP program could be written as follows and the same results achieved.

```
DMAP      BEGIN      $
loop      { MOD1      A/B  $
           LABEL      L1  $
           MOD2      B/BB $
           EQUIV      BB,B/LINK $
           REPT      L1,1 $
           MOD3      B//  $
           END        $
```

Data block BB is now internal; therefore, the instruction EQUIV B,BB/BREAK \$ is not needed.

5.2.3.3 The PURGE Instruction (see Section 5.7)

The status of a data block is changed to purged by explicitly or implicitly purging it. A data block is explicitly purged through the PURGE instruction, whereas it is implicitly purged if it is not created by the functional module in which it appears as an output.

The primary purpose of the PURGE instruction is to prepurge data blocks. Prepurging is the explicit purging of a data block prior to its appearance as output from a functional module. Prepurging data blocks allows the NASTRAN executive system to allocate available files more efficiently which decreases problem execution time. The DMAP programmer should look for data blocks that can be prepurged and purge them as soon as it is recognized that they will not be generated.

Sometimes during the execution of a problem it is necessary to generate a data block whose status is purged. This situation can occur both in DMAP looping and in a modified restart situation. In order to generate a data block that is purged it is first necessary to unpurge it (i.e., change its status from purged to not generated). Unpurging is achieved by executing a PURGE instruction which references the purged data block and whose purge parameter is positive.

The PURGE instruction thus has two functions, to unpurge as well as purge data blocks depending on the value of the purge parameter and the status of the referenced data block. The following table shows what action is taken by the PURGE instruction for all combinations of input.

DIRECT MATRIX ABSTRACTION

PURGE A/P \$		
Status of data block A prior to PURGE	Value of P	Status of Data block A after PURGE
Not generated Not generated	$P \geq 0$ $P < 0$	Not generated (i.e., no action taken) Purged
Generated Generated	$P \geq 0$ $P < 0$	Generated (i.e., no action taken) Purged
Purged Purged	$P \geq 0$ $P < 0$	Not generated (i.e., unpurged) Purged (i.e., no action taken)

The user may wonder why he should not prepurge all data blocks and then unpurge them when necessary in order to really assist the file allocator. One should not do this, since there is a limited amount of space in the table where the status of data blocks is kept. One may overflow this table if too many data blocks are purged at one time. Therefore, only prepurge those data blocks that can truly be prepurged.

EXAMPLE of explicit and implicit purging and prepurging.

```

BEGIN      $
MØD1      IP/A/V,Y,PX/V,Y,PY/V,Y,PB $
SAVE      PX,PY,PB $
PURGE     X/PX / Y/PY $
MØD2      A/B,C,D/V,Y,PB/V,Y,PC $
SAVE      PC $
PURGE     C/PC $
MØD3      B,C,D/E $
MØD4      E/X,Y,Z $
MØD5      X,Y,Z// $
END        $

```

Assume that module MØD1 sets $PX < 0$, $PY \geq 0$ and $PB = 0$. Assume that B is not generated by MØD2 if $PB = 0$. Assume that MØD2 sets $PC < 0$, but does not change PB.

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table.

DMAP RULES

Module being executed	Input status and comments	Output status and comments
MØD1	IP-assumed generated by the input file processor	A - generated PX < 0, PY ≥ 0, PB = 0
SAVE	PX < 0, PY ≥ 0; PB = 0	Parameter values are saved for use in subsequent modules.
PURGE	X,Y-not generated PX < 0, PY ≥ 0	X - purged (i.e., prepurged) Y - not generated
MØD2	A - generated; PB = 0	B - purged (i.e., implicitly); C, D - generated; PC < 0.
SAVE	PC < 0	PB value not saved since MØD2 did not reset it.
PURGE	C - generated PC < 0	C - purged
MØD3	B, C - purged D - generated	E - generated
MØD4	E - generated	X - purged; Y - generated; Z - generated
MØD5	X - purged Y, Z - generated	Output to printer (assumed)
END		Normal termination of problem.

EXAMPLE of unpurging.

```

DMAP loop {
  BEGIN $
  FILE X=SAVE/Y=SAVE $
  FILE Z=APPEND $
  MØD1 IP/A $
  LABEL L1 $
  CØND L2,NPX $
  PURGE X/NPX $
  MØD2 A/X,Y/V,Y,PX=0/V,N,NPX=0 $
  SAVE PX,NPX $
  PURGE X/PX $
  LABEL L2 $
  MØD3 X,Y/Z $
  REPT L1,2 $
  MØD4 Z// $
  END $
}

```

Assume that MØD2 sets PX<0 and NPX≥0 the first time it is executed. Assume that MØD2 sets PX ≥ 0 and NPX < 0 the second time it is executed.

The following table shows what happened when the above DMAP program is executed. Only modules being executed are shown in the table.

DIRECT MATRIX ABSTRACTION

Module being executed	Input status and comments	Output status and comments
MØD1	IP-assumed generated by input file processor.	A - generated
CØND	NPX = 0	Jump not executed
PURGE	X - not generated	X - not generated (i.e., no action taken)
MØD2	A - generated	X, Y - generated; PX < 0, NPX ≥ 0
SAVE	PX < 0, NPX ≥ 0	
PURGE	X - generated; PX < 0	X - purged
MØD3	X - purged; Y - generated	Z - generated
REPT	Loop count = 2	Transfer to location L1; Loop count = 1
CØND	NPX ≥ 0	Jump not executed
PURGE	X - purged; NPX ≥ 0	X - not generated (i.e., unpurged)
MØD2	A - generated	X - generated; Y - generated (note old data for Y is lost because Y not Appended); PX ≥ 0, NPX < 0
SAVE	PX ≥ 0, NPX < 0	
PURGE	X - generated; PX ≥ 0	X - generated (i.e., no action taken)
MØD3	X,Y - generated	Z - generated (note new data appended to old because Z declared appended)
REPT	Loop count = 1	Transfer to location L1; Loop count = 0
CØND	NPX < 0	Transfer to location L2
MØD3	X, Y - generated	Z - generated (i.e., appended)
REPT	Loop count = 0	Fall through to next instruction
MØD4	Z - generated	Output to printer (assumed)
END		Normal termination of problem

5.2.3.4 The CHPNT Instruction (see Section 5.7)

The CHPNT instruction provides the user with a means for saving data blocks for subsequent restart of his problem with a minimum amount of redundant processing. The following rules will assure the DMAP programmer of the most efficient restart.

1. Checkpoint all output data blocks from every functional module.

DMAP RULES

2. Checkpoint all data blocks mentioned in a PURGE instruction.
3. Checkpoint all secondary data blocks in an EQUIV instruction. Never checkpoint primary data blocks in an EQUIV instruction.

EXAMPLE of checkpointing.

```
BEGIN $
MOD1  A/B,C/V,Y,P1/V,Y,P2 $
SAVE  P1,P2 $
CHKPNT B,C $
PURGE X,Y/P1 / Z/P2 $
CHKPNT X,Y,Z $
EQUIV B,BB/P1 / C,CC,D/P2 $
CHKPNT BB,CC,D $
.
.
.
END $
```

In the example the data blocks were checkpointed as soon as possible, which is the most straightforward way, but it required three calls to the checkpoint module, which increases problem execution time. Since checkpointing usually requires a small fraction of the total execution time, it is recommended that the user use the most straightforward method to avoid trouble. The rigid format DMAP sequences have been designed for efficiency and, consequently, they appear more complex than they really are.

DIRECT MATRIX ABSTRACTION

5.3 INDEX OF DMAP MODULE DESCRIPTIONS

Descriptions of all nonstructurally oriented Modules are contained herein, arranged alphabetically by category as indicated by the lists below. Descriptions for the structurally oriented modules are contained in Section 4 of the Programmer's Manual. They are listed here in order to provide a complete list of all NASTRAN Modules. Additional information regarding nonstructurally oriented modules is also given in Section 4 of the Programmer's Manual.

Matrix Operation Modules (12) (See Section 5.4)

ADD	PARTN
ADD5	SMPYAD
DECØMP	SØLVE
FBS	TRNSP
MERGE	UMERGE
MPYAD	UPARTN

Utility Modules (23) (See Section 5.5)

DIAGØNAL	PARAML
INPUT	PARAMR
INPUTT1	PRTPARAM
INPUTT2	PVEC
MATGPR	SCALAR
MATPRN	SEEMAT
MATPRT	SETVAL
ØOUTPUT1	TABPCH
ØOUTPUT2	TABPRT
ØOUTPUT3	TABPT
PARAM	TIMETEST
	VEC

User Modules (14) (See Section 5.6)

DDR	MØDA
DUMMØD1	MØDB
DUMMØD2	MØDC
DUMMØD3	ØUTPUT
DUMMØD4	ØUTPUT4
INPUTT3	PARTVEC
INPUTT4	XYPRNPLT

Executive Operation Modules (12) (See Section 5.7)

BEGIN	FILE
CHKPNT	JUMP
CØND	LABEL
END	PURGE
EQUIV	REPT
EXIT	SAVE

Structurally Oriented Modules (68)

(See Section 4 of the Programmer's Manual)

BMG	GPCYC	PLA4	SMA1
CASE	GPFDR	PLØT	SMA2
CEAD	GP1	PLTSET	SMA3
DDR1	GP2	PLTTRAN	SMP1
DDR2	GP3	PRTMSG	SMP2
DDRMM	GP4	RANDØM	SSGHT
DPD	GPSP	RBMG1	SSG1
DSCHK	GPWG	RBMG2	SSG2
DSMG1	MCE1	RBMG3	SSG3
DSMG2	MCE2	RBMG4	SSG4
EMA	MTRXIN	READ	TA1
EMG	ØFP	RMG	TRD
FA1	ØPTPR1	SCE1	TRHT
FA2	ØPTPR2	SDR1	TRLG
FRRD	PLA1	SDR2	VDR
GKAD	PLA2	SDR3	XYPLØT
GKAM	PLA3	SDRHT	XYTRAN

DIRECT MATRIX ABSTRACTION

In the examples that accompany each description, the following notation is used:

1. Upper case letters and special symbols in the DMAP calling sequence must be punched as shown except for data block names, parameter names, and label names which are symbolic.
2. Lower case letters represent constants whose permissible values are indicated in the descriptive text.

Due to the many possible forms which may be used when writing parameters, a variety of arbitrarily selected forms will be used in the examples. This does not imply that the form used in any example is required or that it is the only acceptable form allowed.

The terms form, type, and precision are used in many functional module descriptions. By form is meant one of the following:

<u>Form</u>	<u>Meaning</u>
1	Square
2	Rectangular
6	Symmetric

By type is meant one of the following:

<u>Type</u>	<u>Meaning</u>
1	Real, single precision
2	Real, double precision
3	Complex, single precision
4	Complex, double precision

By precision is meant one of the following:

<u>Precision Indicator</u>	<u>Meaning</u>
1	Single precision numbers
2	Double precision numbers

INDEX OF DMAP MODULE DESCRIPTIONS

Substructure DMAP ALTERs (19) (see Section 5.9)

BRECOVER	REDUCE
CHECK	RENAME
COMBINE	RESTORE
DELETE	RUN
DESTROY	SØFIN
DUMP	SØFØUT
EDIT	SØFPRINT
EQUIV	SØLVE
PLØT	SUBSTRUCTURE
RECOVER	

DIRECT MATRIX ABSTRACTION

5.4 MATRIX OPERATIONS MODULES

<u>Module</u>	<u>Basic Operation</u>	<u>Page</u>
ADD	$[X] = a[A] + b[B]$	5.4-2
ADD5	$[X] = a[A] + b[B] + c[C] + d[D] + e[E]$	5.4-3
DECOMP	$[A] \Rightarrow [L][U]$	5.4-4
FBS	$[X] = ([L][U])^{-1} [B]$	5.4-5
MERGE	$[A] \Leftarrow \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}$	5.4-7
MPYAD	$[X] = [A][B] + [C]$	5.4-9
PARTN	$[A] \Rightarrow \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}$	5.4-11
SMPYAD	$[X] = [A][B][C][D][E] + [F]$	5.4-14
SOLVE	$[X] = [A]^{-1} [B]$	5.4-16
TRNSP	$[X] = [A]^T$	5.4-18
UMERGE	$\{PHIF\} \Leftarrow \begin{Bmatrix} PHIA \\ PHI\emptyset \end{Bmatrix}$	5.4-19
UPARTN	$[K_{ii}] = \begin{bmatrix} K_{jj} & K_{jl} \\ K_{lj} & K_{ll} \end{bmatrix}$	5.4-20

DIRECT MATRIX ABSTRACTION

I. NAME: ADD (Matrix Add)

II. PURPOSE: To compute $[X] = a[A] + b[B]$ where a and b are scale factors.

III. DMAP CALLING SEQUENCE:

ADD A,B / X / C,Y,ALPHA=(1.0,2.0) / C,Y,BETA=(3.0,4.0) \$

IV. INPUT DATA BLOCKS:

A - Any matrix

B - Any matrix

Note: [A] and/or [B] may be purged, in which case the corresponding term in the matrix sum will be assumed null. The input data blocks must be unique.

V. OUTPUT DATA BLOCKS:

X - matrix.

The type of [X] is maximum of the types of [A], [B], a, b. The size of [X] is the size of [A] if [A] is present. Otherwise it is that of [B].

Note: [X] cannot be purged.

VI. PARAMETERS:

ALPHA - Input-complex-single precision, default = (1.0, 0.0). This is a, the scalar multiplier for [A].

BETA - Input-complex-single precision, default = (1.0, 0.0). This is b, the scalar multiplier for [B].

Note: If $\text{Im}(\text{ALPHA})$ or $\text{Im}(\text{BETA}) = 0.0$ the corresponding parameter will be considered real.

MATRIX OPERATIONS MODULES

I. NAME: ADD5 (Matrix Add)

II. PURPOSE: To compute $[X] = a[A] + b[B] + c[C] + d[D] + e[E]$ where a, b, c, d and e are scale factors.

III. DMAP CALLING SEQUENCE:

ADD5 A,B,C,D,E / X / C,Y,ALPHA=(1.0,2.0) / C,Y,BETA=(3.0,4.0) / C,Y,GAMMA=(5.0,6.0) /
C,Y,DELTA=(7.0,8.0) / C,Y,EPSLN=(9.0,1.0) \$

IV. INPUT DATA BLOCKS:

A, B, C, D, and E must be distinct matrices.

Note: Any of the matrices may be purged, in which case the corresponding term in the matrix sum will be assumed null. The input data blocks must be unique.

V. OUTPUT DATA BLOCKS:

X - matrix.

The type of [X] is maximum of the types of A, B, C, D, E, a, b, c, d, e. The size of [X] is the size of the first nonpurged input.

Note: [X] cannot be purged.

VI. PARAMETERS:

ALPHA - Input-complex-single precision, default = (1.0, 0.0). This is a, the scalar multiplier for [A].

BETA - Input-complex-single precision, default = (1.0, 0.0). This is b, the scalar multiplier for [B].

GAMMA - Input-complex-single precision, default = (1.0, 0.0). This is c, the scalar multiplier for [C].

DELTA - Input-complex-single precision, default = (1.0, 0.0). This is d, the scalar multiplier for [D].

EPSLN - Input-complex-single precision, default = (1.0, 0.0). This is e, the scalar multiplier for [E].

Note: If Im(ALPHA), Im(BETA), Im(GAMMA), Im(DELTA), or Im(EPSLN) = 0.0, the corresponding parameter will be considered real.

DIRECT MATRIX ABSTRACTION

I. DECOMP (Matrix Decomposition)

- II. PURPOSE: To decompose a square matrix [A] into upper and lower triangular factors [U] and [L] .

$$[A] \Rightarrow [L][U]$$

III. DMAP CALLING SEQUENCE:

DECOMP A / L,U / V,Y,KSVM / V,Y,CHOLSKY / V,N,MINDIAG / V,N,DET / V,N,POWER / V,N,SING \$

IV. INPUT DATA BLOCKS:

A - A square matrix

V. OUTPUT DATA BLOCKS:

L - Nonstandard lower triangular factor of [A].

U - Nonstandard upper triangular factor of [A].

VI. PARAMETERS:

KSVM - Input-integer, default = 1. 1, use symmetric decomposition. 0, use unsymmetric decomposition.

CHOLSKY - Input-integer, default = 0. 1, use Cholesky decomposition - matrix must be positive definite. 0, do not use Cholesky decomposition.

MINDIAG - Output-real double precision, default = 0.000. The minimum diagonal term of [U].

DET - Output-complex single precision, default = 0.000. The scaled value of the determinant of [A].

POWER - Output-integer, default = 0. Integer POWER of 10 by which DET should be multiplied to obtain the determinant of [A].

SING - Output-integer, default = 0. SING is set to -1 if [A] is singular.

VII. REMARKS:

1. Non-standard triangular factor matrix data blocks are used to improve the efficiency of the back substitution process in module FBS. The format of these data blocks is given in Section 2 of the Programmer's Manual.
2. The matrix manipulating utility modules should be cautiously employed when dealing with non-standard matrix data blocks.
3. If the CHOLSKY option is selected, the resulting factor (which will be written as [U]) cannot be input to FBS.
4. Variable parameters output from functional modules must be SAVED if they are to be subsequently used. See the Executive Module SAVE description.

MATRIX OPERATIONS MODULES

I. NAME: FBS (Matrix Forward-Backward Substitution)

II. PURPOSE: To solve the matrix equation $[L][U][X] = \pm [B]$ where $[L]$ and $[U]$ are the lower and upper triangular factors of a matrix previously obtained via Functional Module DECØMP.

III. DMAP CALLING SEQUENCE:

FBS L,U,B / X / V,Y,SYM / V,Y,SIGN / V,Y,PREC / V,Y,TYPE \$

IV. INPUT DATA BLOCKS:

L - Nonstandard lower triangular factor

U - Nonstandard upper triangular factor

B - Rectangular matrix

V. OUTPUT DATA BLOCKS:

X - Rectangular matrix having the same dimensions as $[B]$.

VI. PARAMETERS:

<p>SYM - Input-integer-default = 0</p> <p>- Output-integer</p>	{	<p>1 - matrix $[L][U]$ is symmetric</p> <p>-1 - matrix $[L][U]$ is unsymmetric</p> <p>0 - reset to 1 or -1 depending upon $[U]$ being purged or not respectively.</p>
		SYM used

<p>SIGN - Input-integer-default = 1.</p>	{	<p>1 - solve $[L][U][X] = [B]$</p> <p>-1 - solve $[L][U][X] = -[B]$</p>
--	---	---

<p>PREC - Input-integer-default = 0</p> <p>- Output-integer</p>	{	<p>1 - use single precision arithmetic</p> <p>2 - use double precision arithmetic</p> <p>0 - logical choice based on input and system precision flag</p>
		Precision used.

<p>TYPE - Input-integer-default = 0</p> <p>- Output-integer</p>	{	<p>1 - output type of matrix $[X]$ is real single precision</p> <p>2 - output type of matrix $[X]$ is real double precision</p> <p>3 - output type of matrix $[X]$ is complex single precision</p> <p>4 - output type of matrix $[X]$ is complex double precision</p> <p>0 - logical choice based on input matrices</p>
		TYPE used.

DIRECT MATRIX ABSTRACTION

VII. REMARKS:

1. Non-standard triangular factor matrix data blocks are used to improve the efficiency of the back substitution process. The format of these data blocks is given in Section 2 of the Programmer's Manual.
2. The matrix manipulating utility modules should be cautiously employed when dealing with non-standard matrix data blocks.

MATRIX OPERATIONS MODULES

I. NAME: MERGE (Matrix Merge)

II. PURPOSE: To form the matrix [A] from its partitions:

$$[A] \leftarrow \begin{array}{c} \begin{array}{|c|} \hline \uparrow \\ \hline \text{RP} \\ \hline \downarrow \\ \hline \end{array} \begin{array}{|c|c|} \hline \text{A11} & \text{A12} \\ \hline \text{A21} & \text{A22} \\ \hline \end{array} \begin{array}{c} \begin{array}{|c|} \hline \leftarrow \text{CP} \rightarrow \\ \hline \end{array} \\ \hline \end{array} \end{array} \begin{array}{l} = 0 \\ \neq 0 \\ = 0 \quad \neq 0 \end{array}$$

III. DMAP CALLING SEQUENCE:

MERGE A11,A21,A12,A22,CP,RP / A / V,Y,SYM / V,Y,TYPE / V,Y,FØRM \$

IV. INPUT DATA BLOCKS:

A11 - Matrix

A21 - Matrix

A12 - Matrix

A22 - Matrix

CP - Column partitioning vector (see below) - Single precision column vector.

RP - Row partitioning vector (see below) - Single precision column vector.

Notes:

1. Any or all of [A11], [A12], [A21], [A22] can be purged. When all are purged this implies [A] = [0].
2. {RP} and {CP} may not both be purged.
3. See Remarks for meaning when either of {RP} or {CP} is purged.
4. [A11], [A12], [A21], [A22] must be unique matrices.

V. OUTPUT DATA BLOCKS:

A - merged matrix from [A11], [A12], [A21], [A22]

Notes: [A] cannot be purged.

VI. PARAMETERS:

SYM - Input-integer, default = -1. SYM < 0, {CP} is used for {RP}. SYM ≥ 0, {CP} and {RP} are distinct.

TYPE - Input-integer, default = 0. Type of [A] - see Remark 4

FØRM - Input-integer, default = 0. Form of [A] - see Remark 3

VII. REMARKS:

1. MERGE is the inverse of PARTN in the sense that if [A11], [A12], [A21], [A22] were produced by PARTN using {RP}, {CP}, FØRM, SYM, and TYPE from [A], MERGE will produce [A]. See PARTN for options on {RP}, {CP} and SYM.
2. All input data blocks must be distinct.
3. When FØRM = 0, a compatible matrix [A] results as shown in the following table:

DIRECT MATRIX ABSTRACTION

		Form of A22		
		Square	Rectangular	Symmetric
Form of A11	Square	Square	Rectangular	Rectangular
	Rectangular	Rectangular	Rectangular	Rectangular
	Symmetric	Rectangular	Rectangular	Symmetric

4. If TYPE = 0, the type of the output matrix will be the maximum type of [A11], [A12], [A21] and [A22].

MATRIX OPERATIONS MODULES

I. NAME: MPYAD (Matrix Multiply and Add)

II. PURPOSE: MPYAD performs the multiplication of two matrices and, optionally, addition of a third matrix to the product. By means of parameters, the user may compute $\pm [A][B] \pm [C] = [X]$, or $\pm [A]^T[B] \pm [C] = [X]$.

III. DMAP CALLING SEQUENCE:

MPYAD A,B,C / X / V,N,T / V,N,SIGNAB / V,N,SIGNC / V,N,PREC \$

IV. INPUT DATA BLOCKS:

A - Left hand matrix in the matrix product $[A][B]$
 B - Right hand matrix in the matrix product $[A][B]$
 C - Matrix to be added to $[A][B]$

Notes:

1. If no matrix is to be added, [C] must be purged.
2. [A], [B], [C] must be physically different data blocks.
3. [A] and [B] must not be purged.

V. OUTPUT DATA BLOCKS:

X - Matrix resulting from the MPYAD operation.

Note: [X] may not be purged.

VI. PARAMETERS:

T - Integer-input, no default. $T = \begin{cases} 1, & \text{perform } [A]^T[B] \\ 0, & \text{perform } [A][B] \end{cases}$

SIGNAB - Integer-input, default = 1. $SIGNAB = \begin{cases} +1, & \text{perform } [A][B] \\ 0, & \text{omit } [A][B] \\ -1, & \text{perform } -[A][B] \end{cases}$

SIGNC - Integer-input, default = 1. $SIGNC = \begin{cases} +1, & \text{add } [C] \\ 0, & \text{omit } [C] \\ -1, & \text{subtract } [C] \end{cases}$

PREC - Integer-input, default = 0. $PREC = \begin{cases} 1, & \text{elements of } [X] \text{ will be output} \\ & \text{in single-precision} \\ 2, & \text{elements of } [X] \text{ will be output} \\ & \text{in double-precision} \\ 0, & \text{logical choice based on input} \\ & \text{and system precision flag} \end{cases}$

DIRECT MATRIX ABSTRACTION

VII. EXAMPLES:

1. $[X] = [A][B] + [C]$ ([X] see notes)
MPYAD A,B,C / X / C,N,0 \$
2. $[X] = [A]^T[B] - [C]$ ([X] single-precision)
MPYAD A,B,C / X / C,N,1 / C,N,1 / C,N,-1 / C,N,1 \$
3. $[X] = -[A][B]$ ([X] see notes)
MPYAD A,B, / X / C,N,0 / C,N,-1 \$

Notes: The precision of [X] is determined from the input matrices in that if anyone of these matrices is specified as double precision, then [X] will also be double precision. If the precision for the input matrices is not specified, the precision of the system flag will be used.

MATRIX OPERATIONS MODULES

I. NAME: PARTN (Matrix Partition)

II. PURPOSE: To partition [A] into [A11], [A12], [A21] and [A22]:

$$[A] \Rightarrow \begin{array}{c} \begin{array}{|c|} \hline \text{RP} \\ \hline \end{array} \begin{array}{|c|c|} \hline \begin{array}{c} \leftarrow \text{CP} \rightarrow \\ \hline \end{array} \\ \hline \end{array} \begin{array}{c} \begin{bmatrix} A11 & A12 \\ A21 & A22 \end{bmatrix} \\ \hline \end{array} \begin{array}{c} = 0 \\ \neq 0 \\ = 0 \quad \neq 0 \end{array} \end{array}$$

III. DMAP CALLING SEQUENCE:

PARTN A,CP,RP / A11,A21,A12,A22 / V,Y,SYM / V,Y,TYPE / V,Y,F11 / V,Y,F21 / V,Y,F12 / V,Y,F22 \$

IV. INPUT DATA BLOCKS:

A - Matrix to be partitioned.

CP - Column partitioning vector - single precision column vector.

RP - Row partitioning vector - single precision column vector.

V. OUTPUT DATA BLOCKS:

A11 - Upper left partition of [A]

A21 - Lower left partition of [A]

A12 - Upper right partition of [A]

A22 - Lower right partition of [A]

Notes: 1. Any or all output data blocks may be purged.
2. For size of outputs see METHOD section below.

VI. PARAMETERS:

SYM - Input-integer, default = -1. SYM chooses between a symmetric partition and one unsymmetric partition. If SYM < 0, {CP} is used as {RP}. If SYM ≥ 0, {CP} and {RP} are distinct.

TYPE - Input-integer, default = 0. Type of output matrices - see Remark 8

F11 - Input-integer, default = 0. Form of [A11].

F21 - Input-integer, default = 0. Form of [A21].

F12 - Input-integer, default = 0. Form of [A12].

F22 - Input-integer, default = 0. Form of [A22].

See Remark 7

VII. METHOD:

Let NC = number of nonzero terms in {CP}.

Let NR = number of nonzero terms in {RP}.

Let NRØWA = number of rows in [A].

Let NCØLA = number of columns in [A].

Case 1 {CP} purged and SYM ≥ 0.

[A11] is a (NRØWA-NR) by NCØLA matrix.

[A21] is a NR by NCØLA matrix.

[A12] is not written.

[A22] is not written.

$$[A] \rightarrow \begin{bmatrix} A11 \\ A21 \end{bmatrix}$$

DIRECT MATRIX ABSTRACTION

CASE 2 {RP} purged and $\text{SYM} \geq 0$

[A11] is a NRØWA by (NCØLA - NC) matrix.

[A21] is not written.

$$[A] \rightarrow [A11 \mid A12]$$

[A12] is a NRØWA by NC matrix.

[A22] is not written.

CASE 3 $\text{SYM} < 0$ ({RP} must be purged)

[A11] is a (NRØWA - NC) by (NCØLA - NC) matrix.

[A21] is a NC by (NCØLA - NC) matrix.

[A12] is a (NRØWA - NC) by NC matrix.

[A22] is a NC by NC matrix.

$$[A] \rightarrow \begin{bmatrix} A11 & | & A12 \\ \hline A21 & | & A22 \end{bmatrix}$$

CASE 4 neither {CP} nor {RP} purged and $\text{SYM} \geq 0$

[A11] is a (NRØWA - NR) by (NCØLA - NC) matrix.

[A21] is a NR by (NCØLA - NC) matrix.

[A12] is a (NRØWA - NR) by NC matrix.

[A22] is a NR by NC matrix.

$$[A] \rightarrow \begin{bmatrix} A11 & | & A12 \\ \hline A21 & | & A22 \end{bmatrix}$$

VIII. REMARKS:

1. If [A] is purged, PARTN will cause all output data blocks to be purged.
2. If {CP} is purged, [A] is partitioned as follows:

$$[A] \Rightarrow \begin{bmatrix} A11 \\ \hline A21 \end{bmatrix}$$

3. If {RP} is purged and $\text{SYM} \geq 0$, [A] is partitioned as follows:

$$[A] \Rightarrow [A11 \mid A12]$$

4. If {RP} is purged and $\text{SYM} < 0$, [A] is partitioned as follows:

$$[A] \Rightarrow \begin{bmatrix} A11 & | & A12 \\ \hline A21 & | & A22 \end{bmatrix}$$

where {CP} is used as both the row and column partitioner.

5. {RP} and {CP} cannot both be purged.

- 6.

$$[A] \Rightarrow \begin{bmatrix} A11 & | & A12 \\ \hline A21 & | & A22 \end{bmatrix}$$

Let [A] be a m by n order matrix.

Let {CP} be a n order row matrix containing q zero elements.

Let {RP} be a m order column vector containing p zero element.

Partition [A11] will consist of all elements A_{ij} of [A] for which $CP_j = RP_i = 0$ in the same order as they appear in [A].

Partition [A12] will consist of all elements A_{ij} of [A] for which $CP_j \neq 0$ and $RP_i = 0$ in the same order as they appear in [A].

MATRIX OPERATIONS MODULES

Partition [A21] will consist of all elements A_{ij} of [A] for which $CP_j = 0$ and $RP_i \neq 0$ in the same order as they appear in [A].

Partition [A22] will consist of all elements A_{ij} of [A] for which $CP_j = 0$ and $RP_i \neq 0$ in the same order as they appear in [A].

7. If the defaults for F11, F21, F12 or F22 are used, the corresponding matrix will be output with a compatible form entered in the trailer.
8. If TYPE = 0, the type of the output matrices will be the type of the input matrix [A].

IX. EXAMPLES:

1. Let [A], {CP} and {RP} be defined as follows:

$$[A] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 5.0 & 6.0 & 7.0 & 8.0 \\ 9.0 & 10.0 & 11.0 & 12.0 \end{bmatrix}, \quad \{CP\} = \begin{bmatrix} 1.0 \\ 0.0 \\ 1.0 \\ 1.0 \end{bmatrix}, \quad \{RP\} = \begin{bmatrix} 0.0 \\ 0.0 \\ 0.0 \\ 1.0 \end{bmatrix}$$

Then, the DMAP instruction

PARTN A,CP,RP / A11,A21,A12,A22 / C,N,1 \$

will create the real double precision matrices

$$\begin{aligned} [A11] &= \begin{bmatrix} 2.0 \\ 6.0 \end{bmatrix}, \quad F11 = 2 & [A12] &= \begin{bmatrix} 1.0 & 3.0 & 4.0 \\ 5.0 & 7.0 & 8.0 \end{bmatrix}, \quad F12 = 2 \\ [A21] &= [10.0], \quad F21 = 1 & [A22] &= [9.0 \quad 11.0 \quad 12.0], \quad F22 = 2 \end{aligned}$$

2. If, in Example 1, the DMAP instruction were written as

PARTN A,CP, / A11,A21,A12,A22 / C,N,1 \$

the resulting matrices would be

$$\begin{aligned} [A11] &= \begin{bmatrix} 2.0 \\ 6.0 \\ 10.0 \end{bmatrix} & [A12] &= \begin{bmatrix} 1.0 & 3.0 & 4.0 \\ 5.0 & 7.0 & 8.0 \\ 9.0 & 11.0 & 12.0 \end{bmatrix} \\ [A21] &= \text{purged} & [A22] &= \text{purged} \end{aligned}$$

3. If, in Example 1, the DMAP instruction were written as

PARTN A,,RP / A11,A21,A12,A22 / C,N,1 \$

the resulting matrices would be

$$\begin{aligned} [A11] &= \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 5.0 & 6.0 & 7.0 & 8.0 \end{bmatrix} & [A12] &= \text{purged} \\ [A21] &= [9.0 \quad 10.0 \quad 11.0 \quad 12.0] & [A22] &= \text{purged} \end{aligned}$$

DIRECT MATRIX ABSTRACTION

I. NAME: SMPYAD (Matrix Series Multiply and Add)

II. PURPOSE: To multiply a series of matrices together:

$$[X] = [A][B][C][D][E] \pm [F]$$

III. DMAP CALLING SEQUENCE:

SMPYAD A,B,C,D,E,F / X / C,N,n / V,N,SIGNX / V,N,SIGNF / V,N,PX / V,N,TA /
V,N,TB / V,N,TC / V,N,TD \$

IV. INPUT DATA BLOCKS:

A }
B }
C } - Up to 5 matrices to be multiplied together, from left to right.
D }
E }
F - Matrix to be added to the above product.

Notes:

1. If one of the five multiplication matrices is required in the product (see parameter n below) and is purged, the multiplication will not be done.
2. If the [F] matrix is purged, no matrix will be added to the product.

V. OUTPUT DATA BLOCKS:

X - Resultant matrix (may not be pre-purged).

VI. PARAMETERS:

1. n = number of matrices involved in the product, counting from the left (integer, input)
2. SIGNX = sign of the product matrix (e.g., [A][B][C][D][E])
= 1 for plus, -1 for minus (integer, input)
3. SIGNF = sign of the matrix to be added to the product matrix (integer, input)
= 1 for plus, -1 for minus
4. PX = output precision of the final result (integer, input)
= 1 for single-precision, 2 for double-precision, 0 logical choice based on input matrices.
5. TA }
TB } = transpose indicators for the [A],[B],[C], and [D] matrices (1 if transposed
TC } matrix to be used in the product; 0 if untransposed) - (integer, input)
TD }

MATRIX OPERATIONS MODULES

Note:

All the parameters except n have default values as follows:

SIGNX = 1 (sign of product is plus)
SIGNF = 1 (sign of added matrix is plus)
PX = 0 (logical choice based on input matrices)
TA
TB } = 0 (use untransposed [A],[B],[C], and [D] matrices in the product)
TC
TD

VII. METHOD:

The method is the same as for the MPYAD module with the following additional remarks:

1. None of the matrices may be diagonal.
2. Except for the final product, all intermediate matrix products are generated in double-precision.
3. The matrices are post-multiplied together from right-to-left, i.e., the first product calculated is the product of matrix n-1 and matrix n.

VIII. EXAMPLES:

1. To compute $[X] = [A][B]^T[C] - [F]$, use

SMPYAD A,B,C,,F / X / C,N,3 / C,N,1 / C,N,-1 / C,N,0 / C,N,0 / C,N,1 \$

2. To compute $[Z] = -[U]^T[V]^T[W]^T[X]^T[Y]$, use

SMPYAD U,V,W,X,Y, / Z / C,N,5 / C,N,-1 / C,N,0 / C,N,0 / C,N,1 / C,N,1 /
C,N,1 / C,N,1 \$

DIRECT MATRIX ABSTRACTION

I. NAME: SØLVE (Linear System Solver)

II. PURPOSE: To solve the Matrix Equation

$$[A][X] = \pm [B]$$

III. DMAP CALLING SEQUENCE:

SØLVE A,B / X / V,Y,SYM / V,Y,SIGN / V,Y,PREC / V,Y,TYPE \$

IV. INPUT DATA BLOCKS:

A - square real or complex matrix

B - rectangular real or complex matrix (if purged, the identity matrix is assumed).

V. OUTPUT DATA BLOCKS:

X - A rectangular matrix

Note: A standard matrix trailer will be written, identifying [X] as a rectangular matrix with the same dimensions as [B] and the type specified.

VI. PARAMETERS:

SYM - Input-integer, default = 0
- Output-integer

$\left\{ \begin{array}{l} -1 - \text{use unsymmetric decomposition} \\ 1 - \text{use symmetric decomposition} \\ 0 - \text{logical choice based on input matrices} \end{array} \right.$
SYM used.

SIGN - Input-integer, default = 1

$\left\{ \begin{array}{l} 1 - \text{solve } [A][X] = [B] \\ -1 - \text{solve } [A][X] = -[B] \end{array} \right.$

PREC - Input-integer, default = 0
- Output-integer

$\left\{ \begin{array}{l} 0 - \text{logical choice based on input} \\ 1 - \text{use single precision arithmetic} \\ 2 - \text{use double precision arithmetic} \end{array} \right.$
PREC used.

MATRIX OPERATIONS MODULES

TYPE - Input-integer, default = 0

- 0 - logical choice based on input
- 1 - output type of matrix [X] is real, single precision
- 2 - output type of matrix [X] is real double precision
- 3 - output type of matrix [X] is complex single precision
- 4 - output type of matrix [X] is complex double precision

- Output-integer TYPE used.

VII. METHOD:

Depending on the SYM flag and the type of [A], one of subroutines SDCOMP, DECOMP, or CDCOMP is called to form $[A] = [L][U]$.

One of FBS or GFBS is then called to solve $[L][Y] = \pm [B]$ and $[U][X] = [Y]$, as appropriate.

DIRECT MATRIX ABSTRACTION

- I. NAME: TRNSP (Matrix Transpose)
- II. PURPOSE: To form $[A]^T$ given $[A]$.
- III. DMAP CALLING SEQUENCE:
TRNSP A/X \$
- IV. INPUT DATA BLOCKS:
A - Any matrix data block.
Note: If $[A]$ is purged, TRNSP will cause $[X]$ to be purged.
- V. OUTPUT DATA BLOCKS:
X - The matrix transpose of $[A]$
Note: $[X]$ cannot be purged.
- VI. PARAMETERS: None.
- VII. REMARKS:
 - 1. Transposition of large full matrices is very expensive and should be avoided if possible (see Section 2.1.4 of the Theoretical Manual).
 - 2. TRNSP currently uses an algorithm which assumes that the matrix is dense. This algorithm is extremely inefficient for sparse matrices. Sparse matrices should be transposed by using MPYAD.

MATRIX OPERATIONS MODULES

- I. NAME: UMERGE (Merges two matrices based on USET)
- II. PURPOSE: To merge two column matrices (such as load vectors or displacement vectors) into a single matrix.
- III. DMAP CALLING SEQUENCE:
UMERGE USET,PHIA,PHIØ / PHIF / V,N,MAJØR=F / V,N,SUBØ=A / V,N,SUB1=L \$
- IV. INPUT DATA BLOCKS:
USET - Uset [or U-set (Dynamics)]
PHIA Any matrices
PHIØ
Note: 1. USET may not be purged.
2. PHIA or PHIØ may be purged in which case their respective elements will be zero.
3. PHIA, PHIØ and PHIF must be related by the following matrix equation

$$\begin{Bmatrix} \text{PHIA} \\ \text{PHIØ} \end{Bmatrix} \Rightarrow \begin{Bmatrix} \text{PHIF} \end{Bmatrix}$$

- V. OUTPUT DATA BLOCKS:
PHIF - matrix
Note: PHIF must not be purged.
- VI. PARAMETERS:
MAJØR - BCD value from table on page 5.3-17 (Input, no default)
SUBØ - BCD value from table on page 5.3-17 (Input, no default)
SUB1 - BCD value from table on page 5.3-17 (Input, no default)
Note: The set equation MAJØR = SUBØ + SUB1 should hold.

DIRECT MATRIX ABSTRACTION

- I. NAME: UPARTN (Partitions a matrix based on USET)
- II. PURPOSE: To perform symmetric partitioning of displacement method matrices (particularly to allow user splitting of long running modules such as SMP1).
- III. DMAP CALLING SEQUENCE:

UPARTN USET,KII / KJJ,KLJ,KJL,KLL / V,N,MAJØR=I / V,N,SUB0=J / V,N,SUB1=L \$

IV. INPUT DATA BLOCKS:

USET - U-set [or U-set (Dynamics)]

KII - Any displacement matrix

Note: 1. USET may not be purged

2. KII may be purged in which case UPARTN will simply return, causing the output matrices to be purged.

V. OUTPUT DATA BLOCKS:

$\left. \begin{array}{l} \text{KJJ} \\ \text{KLJ} \\ \text{KJL} \\ \text{KLL} \end{array} \right\}$ matrix partitions

Note: 1. Any or all output data block(s) may be purged.

2. UPARTN forms:

$$[K_{ii}] \Rightarrow \begin{bmatrix} K_{jj} & K_{jl} \\ K_{lj} & K_{ll} \end{bmatrix}$$

VI. PARAMETERS:

MAJØR - BCD value from table on page 5.3-17 (Input, no default)

SUB0 - BCD value from table on page 5.3-17 (Input, no default)

SUB1 - BCD value from table on page 5.3-17 (Input, no default)

Note: The set equation MAJØR = SUB0 + SUB1 should hold.

MATRIX OPERATIONS MODULES

VII. EXAMPLE:

In Rigid Format 3 module SMP1 performs the following calculations:

SMP1 partitions the constrained stiffness and mass matrices

$$[K_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right]$$

and

$$[M_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array} \right]$$

solves for transformation matrix

$$[G_o] = -[K_{oo}]^{-1} [K_{oa}]$$

and performs the matrix reductions

$$[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}]^T [G_o]$$

and

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}]^T [G_o] + [G_o]^T [M_{oa}] + [G_o]^T [M_{oo}] [G_o]$$

Step 1 can be performed by two applications of UPARTN:

UPARTN USET,KFF / KAAB,K0A,,K00 / C,N,F / C,N,A / C,N,0 \$

UPARTN USET,MFF / MAAB,M0A,,M00 / C,N,F / C,N,A / C,N,0 \$

Step 2 can be performed by SOLVE

SOLVE K00,K0A / G0 / C,N,1 / C,N,-1 \$

KAA and MAA can be computed by a sequence of applications of the MPYAD module.

Note that checkpoints can be inserted as desired to breakup a long running module into several smaller steps.

DIRECT MATRIX ABSTRACTION

5.5 UTILITY MODULES

<u>Module</u>	<u>Basic Function</u>	<u>Page</u>
DIAGØNAL	Strip diagonal from matrix	5.5-2
INPUT	Generate most of bulk data for selected academic problems	5.5-3
INPUTT1	Read data blocks from GINØ-written user tapes	5.5-4
INPUTT2	Read data blocks from FØRTRAN-written user tapes	5.5-10
MATGPR	Print Matrices with Grid Point Identification	5.5-13
MATPRN	Print Matrices	5.5-15
MATPRT	Print Matrices associated only with geometric grid points	5.5-16
ØUTPUT1	Write data blocks via GINØ onto user tapes	5.5-17
ØUTPUT2	Write data blocks via FØRTRAN onto user tapes	5.5-24
ØUTPUT3	Punch matrices onto DMI cards	5.5-28
PARAM	Manipulate Parameter values	5.5-30
PARAML	Selects parameters from a user input matrix or table	5.5-32
PARAMR	Performs specified arithmetic, logical and conversion operations on real or complex parameters	5.5-33
PRTPARAM	Print parameter values and DMAP error	5.5-35
PVEC	Substructure Analysis Partitioning Vector Data Generator	5.5-37
SCALAR	Convert Matrix element to parameter	5.5-39
SEEMAT	Generate Matrix Topology Displays	5.5-40
SETVAL	Set parameter values	5.5-43
TABPCH	Punch NASTRAN tables on DTI cards	5.5-44
TABPRT	Print selected table data blocks using readable format	5.5-45
TABPT	Print table data blocks	5.5-47
TIMETEST	Provides NASTRAN system timing data	5.5-48
VEC	Generate partitioning vector	5.5-49

Utility modules are an arbitrary sub-division of the Functional Modules and are used to output matrix and table data blocks and to manipulate parameters.

The data block names corresponding to the various matrix and table data blocks used in the Rigid Format DMAP sequences may be found in Section 3 or in the NASTRAN mnemonic dictionary, Section 7.

DIRECT MATRIX ABSTRACTION

- I. NAME: DIAGØNAL (Strip diagonal from matrix)
- II. PURPOSE: To remove the real part of the diagonal from a matrix, raise each term to a specified power, and output a column vector or square symmetric matrix.
- III. DMAP CALLING SEQUENCE:
DIAGØNAL A/B/C,Y,ØPT=CØLUMN/V,Y,PØWER=1. \$
- IV. INPUT DATA BLOCKS:
A - can be any square or diagonal matrix.
- V. OUTPUT DATA BLOCKS:
B - is either a real column vector or symmetric matrix containing the diagonal of A.
- VI. PARAMETERS:
OPT - Input-bcd, default=CØLUMN
 ='CØLUMN' - produces column vector output (labeled as a general rectangular matrix)
 ='SQUARE' - produces square matrix (labeled a symmetric matrix)
POWER - Input-real single precision, default = 1. Exponent to which the real part of each diagonal element is raised.
- VII. REMARKS:
1. The module checks for special cases of PØWER=0.,0.5,1.0,and 2.
2. The precision of the output matrix matches the precision of the input matrix.

UTILITY MODULES

- I. NAME: INPUT (Input Generator)
- II. PURPOSE: Generates the majority of the bulk data cards for selected academic problems.
Used in many of the official NASTRAN Demonstration Problems.
- III. DMAP CALLING SEQUENCE:
INPUT I1,I2,I3,I4,I5 / 01,02,03,04,05 / C,N,a / C,N,b / C,N,c \$
- IV. INPUT DATA BLOCKS:
Appropriate preface outputs.
- V. OUTPUT DATA BLOCKS:
Appropriate for the problem being generated.
- VI. PARAMETERS:
The three parameters are used in conjunction with data read by INPUT from the input stream to define the problem being generated.
- VII. METHOD:
Since INPUT is intimately related to bulk data card input, a detailed description of this module has been placed in Section 2.6.

DIRECT MATRIX ABSTRACTION

- I. NAME: INPUT1 (Reads User Tapes)
(The companion module is OUTPUT1)
- II. PURPOSE: Recovers up to five data blocks from a user tape and checks the user tape label where the expected format is that created by Utility Module OUTPUT1. Also used to position the user tape (including handling of multiple reel tapes) prior to reading the data blocks. Multiple calls are allowed. A message is written for each data block successfully recovered and after each tape reel switch.*
- III. DMAP CALLING SEQUENCE:
INPUT1 / DB1,DB2,DB3,DB4,DB5 / V,N,P1 / V,N,P2 / V,N,P3 \$
- IV. INPUT DATA BLOCKS:
Input data blocks are not used in this module call statement.
- V. OUTPUT DATA BLOCKS:
DBi - Data blocks which will be recovered from one of the NASTRAN permanent tape files INPT, INP1, INP2, through INP9. Any or all of the output data blocks may be purged. Only non-purged data blocks will be taken from the tape. The data blocks will be taken sequentially from the tape starting from a position determined by the value of the first parameter. Note that the output data block sequence A,B,,, is the same as ,A,,B, or ,,,A,B.

*Currently user tape reel switching is available on IBM 360/370 and Univac 1108 only.

UTILITY MODULES

VI. PARAMETERS: The meaning of the first parameter (P1) value is given in the table below.
(The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before reading.
0	Data blocks are read starting at the current position. The current position for the first use of a tape is at the label (P3). Hence, P3 counts as one Data Block.
-1	Rewind before reading, position tape past label (P3).
-2	Mount new reel and position new reel past label (P3) before reading.
-3	Print data block names and then <u>rewind</u> before reading.
-4	Current tape reel will have an end-of-file mark written on it, will be rewound and dismounted and then a new tape reel will be mounted with ring out and rewind before reading the data blocks. This option should be used when a call to INPUT1 is preceded by a call to OUTPUT1 using the same User Tape.
-5	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, <u>fatal</u> termination occurs.
-6	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, <u>fatal</u> termination occurs.
-7	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.
-8	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.

DIRECT MATRIX ABSTRACTION

The second parameter (P2) for this module is the User Tape Code shown in the table below. (The default value is 0).

User Tape Code	GINØ File Name
0	INPT
1	INP1
2	INP2
3	INP3
4	INP4
5	INP5
6	INP6
7	INP7
8	INP8
9	INP9

The third parameter (P3) for this module is used as the User Tape Label for NASTRAN identification. The label (P3) is an alphanumeric variable of eight characters or less (the first character must be alphabetic). The value of P3 must match a corresponding value on the user tape. The comparison of P3 and the value on the user tape is dependent on the value of P1 as shown in the table below. (The default value for P3 is XXXXXXXX).

P1 Value	Tape Label Checked
+n	No
0	No
-1	Yes
-2	Yes (On new reel)
-3	Yes (Warning Check)
-4	Yes (On new reel)
-5	Yes
-6	Yes
-7	Yes
-8	Yes

UTILITY MODULES

VII. EXAMPLES: (Most examples use the default value for P2 and P3 which means the use of permanent NASTRAN tape file INPT and NASTRAN user tape label of XXXXXXXX)

1. INPUTT1 / A,B,,, / \$

Read data blocks A and then B from user tape INPT starting from wherever INPT is currently positioned. If this is the first module to manipulate INPT, the tape will automatically be initially positioned at the beginning of the user tape label. In this case the first parameter of INPUTT1 must be set to either one (1) to skip past the label or minus one (-1) to rewind the tape and position it at the beginning of the first data block (A).

2. INPUTT1 / ,,,, / C,N,-1 / C,N,3 \$

Rewind INP3 and check user tape label.

3. INPUTT1 / A,,,, / C,N,-2 \$

Mount a new reel of tape (without write ring) for INPT and read data block A from the first file position. The label of the new reel of tape will be checked.

4. INPUTT1 / ,,,, / C,N,-2 \$

INPUTT1 / A,,,, / C,N,0 \$

This is equivalent to example 3.

5. INPUTT1 / A,B,C,D,E / C,N,14 \$

Starting from the current position, skip forward 14 data blocks on INPT and read the next five data blocks into A,B,C,D, and E. Do not check the user tape label.

6. INPUTT1 / ,,,, / C,N,-3 \$

INPUTT1 / A,B,C,D,E / C,N,14 \$

A complete list of data block names will be provided including a warning check of the user tape label. Then, it will be the same as example 5 only if the current position in that example were at the beginning of the first data block.

7. INPUTT1 / ,,,, / C,N,-2 \$

INPUTT1 / ,,,, / C,N,-3 \$

INPUTT1 / A,B,,, / C,N,14 \$

Mount a new reel of tape for INPT and check the new reel's label. Print the names of all data blocks on the new tape and give a warning check for tape label. Read the 15th and 16th data blocks into A and B. INPT will end up positioned at the beginning of the 17th data block if present.

DIRECT MATRIX ABSTRACTION

VIII. MORE DIFFICULT EXAMPLES USING BOTH INPUT1 and OUTPUT1:

Example 1:

(a) Objectives:

- (1) Obtain printout of the names of all data blocks on INPT.
- (2) Skip past the first four data blocks, replace the next two with data blocks A and B, and retain the next three data blocks.
- (3) Obtain printout of the names of all data blocks on INPT after (2) has been done.

(b) DMAP Sequence:

BEGIN \$	(1)
INPUT1 / , , , , / C,N,-3 \$	(2)
INPUT1 / , , T1,T2,T3 / C,N,6 \$	(3)
INPUT1 / , , , , / C,N,-1 \$	(4)
OUTPUT1 A,B,T1,T2,T3 // C,N,4 \$	(5)
OUTPUT1, , , , // C,N,-3 \$	(6)
END \$	(7)

(c) Remarks:

- (1) DMAP sequence (2) accomplishes objective (1) and rewinds INPT.
- (2) DMAP sequence (3) recovers data blocks 7, 8, and 9. This is necessary because they would be effectively destroyed by anything written in front of them on INPT.
- (3) DMAP sequence (4) rewinds INPT.
- (4) DMAP sequence (5) accomplishes objective (2).
- (5) DMAP sequence (6) accomplishes objective (3) and leaves INPT positioned after the ninth file, ready to receive additional data blocks.
- (6) Note that INPUT1 is used whenever possible to avoid the possibility of mistakenly writing on INPT prematurely.

UTILITY MODULES

Example 2:

(a) Objectives:

- (1) Write data blocks A, B, and C on INPT.
- (2) Obtain printout of the names of all data blocks on INPT after step (1).
- (3) Make two copies of the tape created in (1).
- (4) Add data blocks D and E to one of the tapes.
- (5) Obtain the names of all data blocks on INPT after (4).

(b) DMAP Sequence:

```
BEGIN $                                (1)
ØUTPUT1 A,B,C,, // C,N,-1 $          (2)
ØUTPUT1 ,,,, // C,N,-3 $             (3)
ØUTPUT1 A,B,C,, // C,N,-2 $          (4)
ØUTPUT1 A,B,C,, // C,N,-2 $          (5)
ØUTPUT1 D,E,, // C,N,0 $              (6)
ØUTPUT1 ,,,, // C,N,-3 $             (7)
END $                                (8)
```

(c) Remarks:

- (1) DMAP Sequence (2) accomplishes objective (1).
- (2) DMAP sequence (3) accomplishes objective (2). The statement INPUTT1 / ,,,, / C,N,-3 \$ will do the same thing and add a rewind.
- (3) Statements (4) and (5) accomplish objective (3).
- (4) Statement (6) accomplishes objective (4) where the third tape is used.
- (5) Statement (7) accomplishes objective (5). The statement INPUTT1 / ,,,, / C,N,-3 \$ will do the same thing and add a rewind.
- (6) On machines where tape reel switching is not implemented, the second parameter can be used as follows:

```
BEGIN $
ØUTPUT1 A,B,C,, // C,N,-1 $
ØUTPUT1 ,,,, // C,N,-3 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,1 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,2 $
ØUTPUT1 D,E,, // C,N,0 / C,N,2 $
ØUTPUT1 ,,,, // C,N,-3 / C,N,2 $
END $
```


DIRECT MATRIX ABSTRACTION

- I. NAME: INPUTT2 (Reads User-Written FØRTRAN Tapes)
(The companion module is ØUTPUT2)
- II. PURPØSE: Recovers up to five data blocks from a FØRTRAN-written user tape. This tape may be written either by a user-written FØRTRAN program or by the companion module ØUTPUT2. The Programmer's Manual describes the format of the tape which must be written in order to be readable by INPUTT2.
- III. DMAP CALLING SEQUENCE:
INPUTT2 / DB1,DB2,DB3,DB4,DB5 / V,N,P1 / V,N,P2 / V,N,P3 \$
- IV. INPUT DATA BLØCKS:
Input data blocks are not used in this module call statement.
- V. ØUTPUT DATA BLØCKS:
DBi - Data blocks which will be recovered from one of the NASTRAN FØRTRAN tape files UT1, UT2, through UT5. Any or all of the output data blocks may be purged. Only non-purged data blocks will be taken from the tape. The data blocks will be taken sequentially from the tape starting from a position determined by the value of the first parameter. Note that the output data block sequence A,B,,, is the same as ,A,,B, or ,,,A,B .

UTILITY MODULES

VI. PARAMETERS: The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before reading.
0	Data blocks are read starting at the current position. The current position for the first use of a tape is at the label (P3). Hence, P3 counts as one Data Block.
-1	Rewind before reading, position tape past label (P3).
-3	Print data block names and then <u>rewind</u> before reading.
-5	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, <u>fatal</u> termination occurs.
-6	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, <u>fatal</u> termination occurs.
-7	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.
-8	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.

DIRECT MATRIX ABSTRACTION

The second parameter (P2) for this module is the FØRTRAN unit number from which the data blocks will be read. This unit is not required to be a physical tape. The allowable values for this parameter are highly machine and installation dependent. Reference should be made to Section 4 of the Programmer's Manual for a discussion of this problem. (The default value for P2 is 0).

User Tape Code	FØRTRAN File Name
11	UT1
12	UT2
13	UT3
14	UT4
15	UT5

The third parameter (P3) for this module is used as the FØRTRAN User Tape Label for NASTRAN identification. The label (P3) is an alphanumeric variable of eight characters or less (the first character must be alphabetic). The value of P3 must match a corresponding value on the FØRTRAN User Tape. The comparison of P3 and the value on the User Tape is dependent on the value of P1 as shown in the table below. (The default value for P3 is XXXXXXXX).

P1 Value	Tape Label Checked
+n	No
0	No
-1	Yes
-3	Yes (Warning Check)
-5	Yes
-6	Yes
-7	Yes
-8	Yes

VII. EXAMPLES:

INPUTT2 is intended to have the same logical action as the GINØ User Tape module INPUTT1 except for tape reel switching. It is therefore suggested that the examples shown under module INPUTT1 be used for INPUTT2 as well, excepting the ones involving tape reel switching.

UTILITY MODULES

- I. NAME: MATGPR (Displacement Approach Matrix Printer)
- II. PURPOSE: Prints matrices generated by the Displacement Approach. External grid point identification of each nonzero element is also printed.
- III. DMAP CALLING SEQUENCE:
 - A. For matrices generated in Rigid Formats 1-6 or matrices generated in Rigid Formats 7-12 prior to module GKAD (or GKAM):

MATGPR GPL, USET, SIL, M // C, N, c / C, N, r \$
 - B. For matrices generated in Rigid Formats 7-12 after module GKAD (or GKAM):

MATGPR GPLD, USETD, SILD, M // C, N, c / C, N, r \$
- IV. INPUT DATA BLOCKS:
 - GPL - Grid Point List
 - GPLD - Grid Point List (Dynamics)
 - USET - U-set
 - USETD - U-set (Dynamics)
 - SIL - Scalar Index List
 - SILD - Scalar Index List (Dynamics)
 - M - Any displacement approach matrix
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS:
 1. c-row size (number of columns) - must be the appropriate BCD value from the table below. (Input, no default)
 2. r-column size (number of rows) - must be the appropriate BCD value from the table below. If not specified, it will be assumed that $r=c$. (Input, default = X which implies $r=c$)

<u>MATGPR parameter value</u>	<u>Means matrix is same size as</u>
M	U_m
\emptyset	U_o
R	U_r
SG	U_s (specified on GRID card)
SB	U_s (specified on SPC card)
L	U_ℓ
A	U_a
F	U_f
S	U_s (union of SG and SB)
N	U_n

DIRECT MATRIX ABSTRACTION

G	U_g
E	U_e
P	U_p
NE	ξ_o
FE	ξ_i
D	U_d
H	U_h

Notes:

1. See Section 3.3 of the Theoretical Manual for a discussion of set notation.
2. If the value specified for c is not in the above table, the matrix will not be printed.
3. The user must know which sets correspond to the rows and columns of the matrix he wishes to print. This is usually apparent from the DMAP name of the matrix data block.

VII. REMARKS:

1. When using the form specified in IIIA, this module may not be scheduled until after GP4 since data blocks generated by GP4 are required inputs. When using the form specified in IIIB, this module may not be scheduled until after DPD since data blocks generated by DPD are required inputs.
2. If [M] is purged, no printing will be done.
3. The non-zero terms of the matrix will be printed along with the external grid point and component identification numbers corresponding to the row and column position of each term.

UTILITY MODULES

- I. NAME: MATPRN (General Matrix Printer)
- II. PURPOSE: To print general matrix data blocks.
- III. DMAP CALLING SEQUENCE:
MATPRN M1,M2,M3,M4,M5 // \$
- IV. INPUT DATA BLOCKS:
Mi - Matrix data blocks, any of which may be purged.
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS: None
- VII. OUTPUT:
The nonzero band of each column of each input matrix data block is unpacked and printed in single precision.
- VIII. NOTES:
 1. Any or all input data blocks can be purged.
 2. If any data block is not matrix type, the TABPT routine will be called.
- IX. EXAMPLES:
 1. MATPRN KGG,,, // \$
 2. MATPRN KGG,PL,PG,BGG,UPV // \$

DIRECT MATRIX ABSTRACTION

I. NAME: MATPRT (Matrix Printer)

II. PURPOSE: To print matrix data blocks associated with grid points only.

III. DMAP CALLING SEQUENCE:

MATPRT X // C,N,rc / C,N,y \$

IV. INPUT DATA BLOCK:

X - matrix data block to be printed. If [X] is purged, then nothing is done.

V. OUTPUT DATA BLOCKS: None

VI. PARAMETERS:

1. rc - indicates whether [X] is stored by rows (rc = 1) or by columns (rc = 0) (integer, input, default value = 0).
2. y - indicates whether [X] is to be printed even if not purged (y < 0, do not print [X]; y ≥ 0, print [X]) (integer, input, default value = 0).

VII. METHOD:

Each column (or row) of the matrix is broken into groups of 6 terms (3 terms if complex) per printed line. If all the terms in a group = 0, the line is not printed. If the entire column (or row) = 0, it is not printed. If the entire matrix = 0, it is not printed.

VIII. REMARKS:

1. MATPRT should not be used if scalar or extra points are present. For this case, use MATPRN.
2. Only one matrix data block is printed by this instruction. The instruction may be repeated as many times as required, however.

UTILITY MODULES

- I. NAME: ØUTPUT1 (Create User Tapes)
(The companion module is INPUT1)
- II. PURPOSE: Writes up to five data blocks and a user tape label onto a user tape for subsequent use at a later date. (See User Module INPUT1 for recovery procedures.)
ØUTPUT1 is also used to position the user tape (including handling of multiple reel tapes*) prior to writing the data blocks. Multiple calls are allowed. A message is written on the output file for each data block successfully written and after each tape reel switch. The user is cautioned to be careful when positioning a user tape with ØUTPUT1 since he may inadvertently destroy information through improper positioning. Even though no data blocks are written, an EOF will be written at the completion of each call which has the effect of destroying anything on the tape forward of the current position.
- III. DMAP CALLING SEQUENCE:
ØUTPUT1 DB1,DB2,DB3,DB4,DB5 // V,N,P1 / V,N,P2 / V,N,P3 \$
- IV. INPUT DATA BLOCKS:
DB1 - Any data block which the user desires to be placed on one of the NASTRAN permanent tape files INPT, INP1, INP2 thru INP9. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be placed on the tape.
- V. ØUTPUT DATA BLOCKS: None.

*User tape reel switching is currently available only on the IBM 360/370 and Univac 1108 computers.

DIRECT MATRIX ABSTRACTION

VI. PARAMETERS: The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before writing.
0	Data Blocks are written starting at the current position. The current position for the first use of a tape is at the label (P3). In this case P3 counts as one Data Block.
-1	Rewind before writing. (This is dangerous!)*
-2	Mount new reel before writing.**
-3	Rewind tape, print data block names and then write after the last data block on the tape.
-4	Current tape reel will be rewound and dis-mounted and a new tape reel will be mounted with <u>ring in</u> and rewound before writing the data blocks. This option should be used when a call to ØUTPUT1 is preceded by a call to INPUTT1 using the same User Tape.

The second parameter (P2) for this module is the User Tape Code shown in the table below. (The default value is 0).

User Tape Code	GINØ File Name
0	INPT
1	INP1
2	INP2
3	INP3
4	INP4
5	INP5
6	INP6
7	INP7
8	INP8
9	INP9

*An EOF is written at the end of each call to ØUTPUT1.

**An end-of-file mark is written on the tape to be switched. Caution should be used when switching from a user tape being read by INPUTT1 to a tape to be written by ØUTPUT1.

UTILITY MODULES

The third parameter (P3) for this module is used to define the User Tape Label. The label is used for NASTRAN identification. The label (P3) is an alphanumeric variable of eight or less characters (the first character must be alphabetic) which is written on the user tape. The writing of this label is dependent on the value of P1 as follows: (The default value for P3 is XXXXXXXX).

P1 Value	Tape Label Written
+n	No
0	No
-1	Yes
-2	Yes (On New Reel)
-3	No (Warning Check)
-4	Yes (On New Reel)

The user may specify the third parameter as V, Y, name. The user then must also include a PARAM card in the bulk data deck to set a value for name.

DIRECT MATRIX ABSTRACTION

VII. EXAMPLES:

1. ØUTPUT1 A,B,,, // C,N,0 / C,N,0 \$ or ØUTPUT1 A,B,,, // \$
Write data blocks A and then B onto user tape INPT starting wherever INPT is currently positioned. If this is the first write operation on INPT it must be preceded by ØUTPUT1 ,,,, // C,N,-1. \$ which will automatically label the tape positioned at its beginning.
2. ØUTPUT1, ,,,, // C,N,-1 / C,N,0 \$
Rewind INPT and destroy any data blocks that were on INPT and write default value of P3 on tape as a label.
3. ØUTPUT1 A,,, // C,N,-2 / C,N,2 / C,N,USERTPA \$
Mount a new reel of tape (with write ring) for INP2 and write USERTPA for user tape label and then data block A as the first file.
4. ØUTPUT1, ,,,, // C,N,-2 / C,N,2 / C,N,USERTPA \$
ØUTPUT1 A,,, // C,N,0 / C,N,2 \$
This is equivalent to example 3.
5. ØUTPUT1 A,B,C,D,E // C,N,14 \$
Starting from the current position, skip forward 14 data blocks on INPT and write A,B,C,D, and E as the next five data blocks. The skip positioning feature cannot be used if the current position of INPT is forward of a just previously written data block end-of-file or before the tape is labeled.
6. ØUTPUT1, ,,,, // C,N,-3 \$ THIS IS AN
ØUTPUT1 A,B,C,D,E // C,N,14 \$ IMPRØPER EXAMPLE.
This is an invalid sequence since the first call positions the tape at the end of all data blocks on the tape. See example 7.
7. INPUTT1 / ,,,, / C,N,-3 \$
ØUTPUT1 A,B,C,D,E // C,N,14 \$
A complete list of data block names will be printed by INPUTT1 which will then rewind the tape. Then, ØUTPUT1 will skip forward 14 data blocks and write A,B,C,D, and E. The user tape label is given a warning check by INPUTT1.
8. ØUTPUT1, ,,,, // C,N,-2 \$ THIS IS AN
ØUTPUT1, ,,,, // C,N,-3 \$ IMPRØPER EXAMPLE.
ØUTPUT1, A,B,,, // C,N,14 \$
This is an invalid sequence since the first call effectively destroys whatever information is on the tape. See example 9.

UTILITY MODULES

9. INPUTT1 / ,,,, / C,N,-2 \$
INPUTT1 / ,,,, / C,N,-3 \$
ØUTPUT1 A,B,,, // C,N,14 \$

Mount a new reel of tape previously default labeled for INPT (the operator will have to be instructed to ignore the NØRING message and put a ring in the tape). Print the names of all data blocks on the tape and rewind the tape. Skip 14 data blocks on the tape and write A and then B as the 15th and 16th data blocks. Any information forward of this current position is effectively destroyed. See example 10.

10. INPUTT1 / ,,,, / C,N,-2 \$
ØUTPUT1 A,B,,, // C,N,-3 \$

Mount a new reel of tape previously default labeled for INPT (the operator will have to be instructed to ignore the NØRING message and put a ring in the tape). Print the names of all data blocks on the tape and write A and B as new data blocks at the end of the tape. If INPT contained 14 data blocks at the start of this sequence, it would be more efficient to do it this way than by using the sequence of example 9 since a pass on the tape is eliminated.

11. INPUTT1 / ,,,, / C,N,-2 / C,N,0 / V,Y,BDSETLAB \$
ØUTPUT1 A,B,,, // C,N,-3 / C,N,0 / V,Y,BDSETLAB \$

This is equivalent to example 10 except the user tape label is set on a PARAM card which must be included in the BULK DATA deck (i.e., PARAM BDSETLAB USERTP12).

DIRECT MATRIX ABSTRACTION

VIII. DIFFICULT EXAMPLES USING INPUT1 and OUTPUT1:

Example 1:

(a) Objectives:

- (1) Obtain printout of the names of all data blocks on INPT.
- (2) Skip past the first four data blocks, replace the next two with data blocks A and B, and retain the next three data blocks.
- (3) Obtain printout of the names of all data blocks on INPT after (2) has been done.

(b) DMAP Sequence:

```
BEGIN $ (1)
INPUT1 / , , , , / C,N,-3 $ (2)
INPUT1 / , , T1,T2,T3 / C,N,6 $ (3)
INPUT1 / , , , , / C,N,-1 $ (4)
OUTPUT1 A,B,T1,T2,T3 // C,N,4 $ (5)
OUTPUT1 , , , , // C,N,-3 $ (6)
END $
```

(c) Remarks:

- (1) DMAP sequence (2) accomplishes objective (1) and rewinds INPT.
- (2) DMAP sequence (3) recovers data blocks 7,8, and 9. This is necessary because they would be effectively destroyed by anything written in front of them on INPT.
- (3) DMAP sequence (4) rewinds INPT.
- (4) DMAP sequence (5) accomplishes objective (2).
- (5) DMAP sequence (6) accomplishes objective (3) and leaves INPT positioned after the ninth file, ready to receive additional data blocks.
- (6) Note that INPUT1 is used whenever possible to avoid the possibility of mistakenly writing on INPT prematurely.

UTILITY MODULES

Example 2:

(a) Objectives:

- (1) Write data blocks A, B, and C on INPT.
- (2) Obtain printout of the names of all data blocks on INPT after step (1).
- (3) Make two copies of the tape created in (1).
- (4) Add data blocks D and E to one of the tapes.
- (5) Obtain the names of all data blocks on INPT after (4).

(b) DMAP Sequence:

```
BEGIN $                                (1)
ØUTPUT1 A,B,C,, // C,N,-1 $           (2)
ØUTPUT1 ,,,, // C,N,-3 $              (3)
ØUTPUT1 A,B,C,, // C,N,-2 $           (4)
ØUTPUT1 A,B,C,, // C,N,-2 $           (5)
ØUTPUT1 D,E,,, // $                   (6)
ØUTPUT1 ,,,, // C,N,-3 $              (7)
END $                                  (8)
```

(c) Remarks:

- (1) DMAP sequence (2) accomplishes objective (1) since the tape must initially have P3 written on it when first used. The DMAP statement ØUTPUT1 A,B,C,, // C,N,-1 \$ will accomplish the same thing.
- (2) DMAP sequence (3) accomplishes objective (2). The statement INPUTT1 / ,,,, / C,N,-3 \$ will do the same thing and add a rewind.
- (3) Statements (4) and (5) accomplish objective (3).
- (4) Statement (6) accomplishes objective (4) where the third tape is used.
- (5) Statement (7) accomplishes objective (5). The statement INPUTT1 / ,,,, / C,N,-3 \$ will do the same thing and add a rewind.
- (6) On machines where tape reel switching is not implemented, the second parameter can be used as follows:

```
BEGIN $
ØUTPUT1 A,B,C,, // C,N,-1 $
ØUTPUT1 ,,,, // C,N,-3 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,1 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,2 $
ØUTPUT1 D,E,,, // C,N,0 / C,N,2 $
ØUTPUT1 ,,,, // C,N,-3 / C,N,2 $
END $
```

DIRECT MATRIX ABSTRACTION

- I. NAME: OUTPUT2 (Create User Written FØRTRAN Tapes)
(The companion module is INPUT2)
- II. PURPOSE: Writes up to five data blocks and a user tape label onto a FØRTRAN-written user tape for subsequent use at a later date. OUTPUT2 is also used to position the user tape prior to writing the data blocks. Multiple calls are allowed. A message is written on the output file for each data block successfully written. The user is cautioned to be careful when positioning a user tape with OUTPUT2 since he may inadvertently destroy information through improper positioning. Even though no data blocks are written, an EØF will be written at the completion of each call which has the effect of destroying anything on the tape forward of the current position.
- III. DMAP CALLING SEQUENCE:
OUTPUT2 DB1,DB2,DB3,DB4,DB5 // V,N,P1 / V,N,P2 / V,N,P3 \$
- IV. INPUT DATA BLOCKS:
DBi - Any data block which the user desires to be written on one of the NASTRAN FØRTRAN tape files UT1, UT2, through UT5. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be placed on the tape.
- V. OUTPUT DATA BLOCKS: None.
- VI. PARAMETERS:
The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before writing.
0	Data Blocks are written starting at the current position. The current position for the first use of a tape is at the label (P3). In this case P3 counts as one Data Block.
-1	Rewind before writing.
-3	Rewind tape, print data block names and then write after the last data block on the tape.
-9	Write a final EØF on the tape.

UTILITY MODULES

The second parameter (P2) for this module is the FORTRAN unit number onto which the data blocks will be written. This unit is not required to be a physical tape. The allowable values for this parameter are highly machine or installation dependent. Reference should be made to Section 4 of the Programmer's Manual for a discussion of this problem. (The default value for P2 is 0).

User Tape Code	FORTRAN File Name
11	UT1
12	UT2
13	UT3
14	UT4
15	UT5

The third parameter (P3) for this module is used to define the FORTRAN User Tape Label. The label is used for NASTRAN identification. The label (P3) is an alphanumeric variable of eight or less characters (the first character must be alphabetic) which is written on the user tape. The writing of this label is dependent on the value of P1 as follows: (The default value for P3 is XXXXXXXX).

P1 Value	Table Label Written
+n	No
0	No
-1	Yes
-3	No (Warning Check)
-9	No

The user may specify the third parameter as V,Y,name. The user then must also include a PARAM card in the bulk data deck to set a value for name.

DIRECT MATRIX ABSTRACTION

VII. EXAMPLES:

ØUTPUT2 is intended to have the same logical action as the GINØ User Tape module ØUTPUT1 except for tape reel switching. It is therefore suggested that the examples shown under module ØUTPUT1 be used for ØUTPUT2 as well, excepting the ones involving tape reel switching. All examples should be ended with a call to ØUTPUT2 with P1 = -9.





VIII. REMARKS:

The primary objective of this module is to write tapes using simple FØRTRAN so that a user can read NASTRAN generated data with his own program. Similarly, matrices can be generated with externally written simple FØRTRAN programs and then read by module INPUTT2.

In order to do this, the format of the information on these tapes must be adhered to. The basic idea is that a one word logical KEY record is written which indicates what follows. A zero value indicates an end-of-file condition. A negative value indicates the end of a record where the absolute value is the record number. A positive value indicates that the next record consists of that many words of data.

UTILITY MODULES

The correspondence between FØRTRAN records and GINØ-written NASTRAN files is shown in the following sample:

FØRTRAN Record	Length	Contents	NASTRAN File	File Record
1	1	KEY > 0	1	1
2	KEY	{Data}  KEY		
3	1	KEY > 0		
4	KEY	{Data}  KEY		
5	1	KEY < 0 (FØP)		
6	1	KEY > 0		2
7	KEY	{Data}  KEY		
8	1	KEY < 0 (EØR)		
9	1	KEY = 0 (EØF)		EØF
10	1	KEY > 0	2	1
11	KEY	{Data}  KEY		
12	1	KEY < 0 (EØR)		
13	1	KEY = 0 (EØF)		EØF
14	1	KEY = 0 (EØF=EØD)	3	EØF

DIRECT MATRIX ABSTRACTION

- I. NAME: ØUTPUT3 (Punch Matrix Data Blocks onto Cards)
- II. PURPOSE: Punches up to five matrix data blocks onto DMI bulk data cards. These cards may then read into NASTRAN as ordinary bulk data to reestablish the matrix data block at a later date.
- III. DMAP CALLING SEQUENCE:
- ```
ØUTPUT3 M1,M2,M3,M4,M5 // C,N,P1 / C,Y,N1=ABC / C,Y,N2=DEF / C,Y,N3=GHI /
C,Y,N4=JKL / C,Y,N5=MNO $
```
- IV. INPUT DATA BLOCKS:
- Mi - Any matrix data block which the user desires to be punched on DMI cards. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be punched.
- V. ØUTPUT DATA BLOCKS: None
- VI. PARAMETERS:

The first parameter (P1) controls the writing of the DMI card images on a FØRTRAN unit as follows:

$P1 < 0$  write on FØRTRAN unit |P1| as well as punch DMI cards

$P1 \geq 0$  punch DMI cards only

The default value for P1 is 0.

Ni - The values of the five BCD parameters shown above are used to create a unique continuation field configuration on the DMI cards. Only the first three characters are used. These three characters must be unique for all matrices which will be input together during a subsequent run using cards generated by ØUTPUT3. (Input, BCD, default values are N1 = no default, N2=N3=N4=N5=XXX).

## UTILITY MODULES

VII. METHOD: The nonzero elements of each matrix are punched on double-field DMI cards as shown in the example below. The name of the matrix is obtained from the header record of the data block. Field 10 contains the three character parameter value in columns 74-76 and an incremented integer card count in columns 77-80.

VIII. EXAMPLE:

Let the data block MAT contain the matrix

$$[MAT] = \begin{bmatrix} 1.0 & 0.0 & 6.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 7.0 & 0.0 & 0.0 & 0.0 \\ 2.0 & 4.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 5.0 & 0.0 & 0.0 & 0.0 & 9.0 \\ 3.0 & 0.0 & 8.0 & 0.0 & 0.0 & 0.0 \end{bmatrix}$$

The DMAP instruction OUTPUT3 MAT,,,, // C,N,0 / C,N,XYZ \$ will then punch out the DMI cards shown below.

|      |     |              |              |   |              |              |   |      |   |
|------|-----|--------------|--------------|---|--------------|--------------|---|------|---|
| DMI  | MAT | 0            | 2            | 1 | 2            | 5            | 6 | +XYZ | 0 |
| DMI* | MAT |              |              | 1 | 1            | 1.000000E 00 |   | *XYZ | 1 |
| *XYZ | 1   | 3            | 2.000000E 00 |   | 5            | 3.000000E 00 |   | *XYZ | 2 |
| DMI* | MAT |              | 2            |   | 3            | 4.000000E 00 |   | *XYZ | 3 |
| *XYZ | 3   | 5.000000E 00 |              |   |              |              |   | *XYZ | 4 |
| DMI* | MAT |              | 3            |   | 1            | 6.000000E 00 |   | *XYZ | 5 |
| *XYZ | 5   | 7.000000E 00 |              | 5 | 8.000000E 00 |              |   | *XYZ | 6 |
| DMI* | MAT |              | 6            |   | 4            | 9.000000E 00 |   | *XYZ | 7 |

IX. REMARKS:

1. Only real single- or double-precision matrices may be output.
2. All matrices are output on double-field cards in single-precision.
3. The maximum number of cards that may be punched is 9999. If matrices larger than this are desired, use module ØUTPUT2 and write a program to process the resulting FØRTRAN file.
4. The auxiliary subroutine PHDMIA used by module ØUTPUT3 can be used with stand-alone FØRTRAN programs. See Section 4 of the Programmer's Manual for details.

## DIRECT MATRIX ABSTRACTION

- I. NAME: PARAM (Parameter Processor)
- II. PURPOSE: To perform specified operations on integer DMAP parameters.
- III. DMAP CALLING SEQUENCE:
- PARAM // C,N,op / V,N,ØUT / V,N,IN1 / V,N,IN2 \$
- IV. INPUT DATA BLOCKS: None
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS:
1. op is a BCD operation code from the table below (Input, no default). Op is usually specified as a "C,N" parameter.
  2. ØUT is the name of the parameter which is being generated by PARAM (output, integer, default = 1).
  3. IN1 is the name of a parameter whose value is used to compute ØUT according to the table below (Input, integer, default = 1).
  4. IN2 is the name of a parameter whose value is used to compute ØUT according to the table below (Input, integer, default = 1).

VII. REMARKS:

1. The table below gives the results for ØUT as a function of op, IN1, and IN2.

| Arithmetic Operations |         |         |         |         |      |
|-----------------------|---------|---------|---------|---------|------|
| op                    | ADD     | SUB     | MPY     | DIV     | NØT  |
| ØUT                   | IN1+IN2 | IN1-IN2 | IN1·IN2 | IN1/IN2 | -IN1 |

| Logical Operations |     |    |    |    |    |    |    |    |      |    |    |    |
|--------------------|-----|----|----|----|----|----|----|----|------|----|----|----|
| op                 | AND |    |    |    | ØR |    |    |    | IMPL |    |    |    |
| ØUT                | -1  | +1 | +1 | +1 | -1 | -1 | -1 | +1 | -1   | +1 | -1 | -1 |
| IN1                | <0  | <0 | ≥0 | ≥0 | <0 | <0 | ≥0 | ≥0 | <0   | <0 | ≥0 | ≥0 |
| IN2                | <0  | ≥0 | <0 | ≥0 | <0 | ≥0 | <0 | ≥0 | <0   | ≥0 | <0 | ≥0 |

| Special Operations |                                                                   |
|--------------------|-------------------------------------------------------------------|
| op                 | ØUT                                                               |
| NØP                | ØUT (unchanged)                                                   |
| KLØCK              | Current CPU time in integer seconds from the start of the job.    |
| TMTØGØ             | Remaining CPU time in integer seconds based on the TIME card.     |
| PREC               | Returns the currently requested precision;<br>2 = D.P. , 1 = S.P. |

2. PARAM does its own SAVE; therefore, a SAVE is not needed following the module.

## UTILITY MODULES

### VIII. EXAMPLES:

1. PARAM // C,N,NØT / V,N,XYZ / V,N,NØXYZ \$ - this example changes the sense of parameter NØXYZ which may be useful for the CØND or EQUIV instructions. Alternatively, XYZ could have been set in the following way:
2. PARAM // C,N,MPY / V,N,XYZ / V,N,NØXYZ / C,N,-1 \$
3. PARAM // C,N,IMPL / V,N,ABC / V,N,DEF / V,N,GHI \$
4. PARAM // C,N,NØP / V,N,P1=5 \$ - this example sets the value of parameter P1 to 5 and saves it for subsequent use.

## DIRECT MATRIX ABSTRACTION

- I. NAME: PARAML (Selects parameters from a list)
- II. PURPOSE: To select parameters from a user input matrix or table.
- III. DMAP CALLING SEQUENCE:
- ```
PARAML INPUT // C,N,ØP / V,N,RECNØ / V,N,WØRDN /  
          V,N,REAL1 / V,N,INTEG / V,N,REAL2 / V,N,BCD $
```
- IV. INPUT DATA BLOCKS:
- INPUT - Any matrix or table
- V. OUTPUT DATA BLOCKS:
- None.
- VI. PARAMETERS:
- ØP - Input-BCD-no default.
 - RECNØ - Input-integer-default = 1
 - WØRDN - Input-integer-default = 1
 - REAL1 - Output-real-default = 1.0
 - INTEG - Output-integer-default = 0
 - REAL2 - Output-real-default = 1.0
 - BCD - Output-BCD-default = blank
- VII. REMARKS:
1. REAL1, INTEG, REAL2, and BCD will be set by the module whenever they are "V" type parameters.
 2. RECNØ and WØRDN control the starting point, according to ØP.
 - If ØP = DMI, RECNØ is the column number and WØRDN is the row number.
 - If ØP = DTI, RECNØ is the record number and WØRDN is the word number.
 - If ØP = PRESENCE, INTEG will be -1 if INPUT is purged.
 3. PARAML does its own SAVE; therefore, a SAVE is not needed following the module.
- VIII. EXAMPLE:
- Obtain the value in column 1, row 1 of a matrix.
- ```
PARAML KGG // C,N,DMI / C,N,1 / C,N,1 / V,N,TERM $
```

## UTILITY MODULES

- I. NAME: PARAMR (Parameter Processor - Real)
- II. PURPOSE: To perform specified arithmetic, logical, and conversion operations on real or complex parameters.
- III. DMAP CALLING SEQUENCE:  

```
PARAMR // C,N,ØP / V,N,ØUTR / V,N,INR1 / V,N,INR2 /
 V,N,ØUTC / V,N,INC1 / V,N,INC2 /
 V,N,FLAG $
```
- IV. INPUT DATA BLOCKS:  
None.
- V. OUTPUT DATA BLOCKS:  
None.
- VI. PARAMETERS:  

```
ØP - Input-BCD operation code from the table below - no default
ØUTR - Output-real-default = 0.0
INR1 - Input-real-default = 0.0
INR2 - Input-real-default = 0.0
ØUTC - Output-complex-default = (0.0,0.0)
INC1 - Input-complex-default = (0.0,0.0)
INC2 - Input-complex-default = (0.0,0.0)
FLAG - Output-integer-default = 0
```

The values of the parameters are dependent upon ØP as shown in the following table:

| <u>ØP</u> | <u>OUTPUTS</u>              |
|-----------|-----------------------------|
| ADD       | ØUTR = INR1 + INR2          |
| SUB       | ØUTR = INR1 - INR2          |
| MPY       | ØUTR = INR1 * INR2          |
| DIV       | ØUTR = INR1 / INR2          |
| NØP       | RETURN                      |
| SQRT      | ØUTR = $\sqrt{\text{INR1}}$ |
| SIN       | ØUTR = SIN(INR1)            |
| CØS       | ØUTR = CØS(INR1)            |
| ABS       | ØUTR =   INR1               |
| EXP       | ØUTR = exp (INR1)           |



# DIRECT MATRIX ABSTRACTION

|                     |                                                                                                    |
|---------------------|----------------------------------------------------------------------------------------------------|
| TAN                 | $\emptyset\text{UTR} = \text{TAN}(\text{INR1})$                                                    |
| N $\emptyset$ RM    | $\emptyset\text{UTR} =    \emptyset\text{UTC}   $                                                  |
| P $\emptyset$ WER   | $\emptyset\text{UTR} = \text{INR1} ** \text{INR2}$                                                 |
| ADDC                | $\emptyset\text{UTC} = \text{INC1} + \text{INC2}$                                                  |
| SUBC                | $\emptyset\text{UTC} = \text{INC1} - \text{INC2}$                                                  |
| MPYC                | $\emptyset\text{UTC} = \text{INC1} * \text{INC2}$                                                  |
| DIVC                | $\emptyset\text{UTC} = \text{INC1} / \text{INC2}$                                                  |
| CSQRT               | $\emptyset\text{UTC} = \sqrt{\text{INC1}}$                                                         |
| C $\emptyset$ MPLEX | $\emptyset\text{UTC} = (\text{INR1}, \text{INR2})$                                                 |
| C $\emptyset$ NJ    | $\emptyset\text{UTC} = \overline{\text{INCT}}$                                                     |
| REAL                | $\text{INR1} = \text{Re} (\emptyset\text{UTC})$<br>$\text{INR2} = \text{Im} (\emptyset\text{UTC})$ |
| EQ                  | $\text{FLAG} = -1 \text{ if } \text{INR1} = \text{INR2}$                                           |
| GT                  | $\text{FLAG} = -1 \text{ if } \text{INR1} > \text{INR2}$                                           |
| LT                  | $\text{FLAG} = -1 \text{ if } \text{INR1} < \text{INR2}$                                           |
| LE                  | $\text{FLAG} = -1 \text{ if } \text{INR1} \leq \text{INR2}$                                        |
| GE                  | $\text{FLAG} = -1 \text{ if } \text{INR1} \geq \text{INR2}$                                        |
| NE                  | $\text{FLAG} = -1 \text{ if } \text{INR1} \neq \text{INR2}$                                        |
| L $\emptyset$ G     | $\emptyset\text{UTR} = \text{L}\emptyset\text{G}_{10} (\text{INR1})$                               |
| LN                  | $\emptyset\text{UTR} = \text{L}\emptyset\text{G}_e (\text{INR1})$                                  |
| FIX                 | $\text{FLAG} = \text{FIX} (\emptyset\text{UTR})$                                                   |
| FL $\emptyset$ AT   | $\emptyset\text{UTR} = \text{FL}\emptyset\text{AT}(\text{FLAG})$                                   |

## VII. REMARKS:

1. Any output parameter must be "V" type if the parameter is used by " $\emptyset$ P" as output.
2. For  $\emptyset$ P = DIV or  $\emptyset$ P = DIVC, the output is zero if the denominator is zero.
3. PARAMR does its own SAVE; therefore, a SAVE is not needed following the module.
4. For  $\emptyset$ P = SIN,  $\emptyset$ P = C $\emptyset$ S or  $\emptyset$ P = TAN, the input must be expressed in radians.

## UTILITY MODULES

- I. NAME: PRTPARM (Parameter and DMAP Message Printer)
- II. PURPOSE: A. Prints parameter values.  
B. Prints DMAP messages.
- III. DMAP CALLING SEQUENCE:  
PRTPARM // C,N,a / C,N,b / C,N,c \$
- IV. INPUT DATA BLOCKS: None
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS:  
a - Integer value (no default value)  
b - BCD value (default value = XXXXXXXX)  
c - Integer value (default value = 0)
- VII. METHOD:  
A. As a parameter printer, use a = 0. There are two options:  
1. b = parameter name will cause the printout of the value of that parameter.  
Example: PRTPARM // C,N,0 / C,N,LUSET \$  
2. b = XXXXXXXX will cause the printout of the values of all parameters in the current variable parameter table. Since this is the default value, it need not be specified.  
Example: PRTPARM // C,N,0 \$  
B. As a DMAP message printer, use a ≠ 0. There are two options:  
1. a > 0 causes the printout of the j<sup>th</sup> message of category b where j=|a| and b is one of the values shown below. (The number of messages available in each category is also given.)  
Example: PRTPARM // C,N,1 / C,N,DMAP \$  
2. a < 0 causes the same action as a > 0 with the additional action of program termination. Thus, PRTPARM may be used as a fatal message printer.  
Example: PRTPARM // C,N,-2 / C,N,PLA \$
- VIII. REMARKS:  
1. b is always a value.  
2. Meaningless values of a and b will result in diagnostic messages from PRTPARM.

# DIRECT MATRIX ABSTRACTION

3.

TABLE OF b CATEGORY VALUES

|    | DISPLACEMENT Rigid Formats                        | Value of b | Number of Messages |
|----|---------------------------------------------------|------------|--------------------|
| 1  | Static Analysis                                   | STATICS    | 5                  |
| 2  | Static Analysis with Inertia Relief               | INERTIA    | 5                  |
| 3  | Normal Mode Analysis                              | MODES      | 3                  |
| 4  | Static Analysis with Differential Stiffness       | DIFFSTIF   | 4                  |
| 5  | Buckling Analysis                                 | BUCKLING   | 6                  |
| 6  | Piecewise Linear Analysis                         | PLA        | 5                  |
| 7  | Direct Complex Eigenvalue Analysis                | DIRCEAD    | 3                  |
| 8  | Direct Frequency and Random Response              | DIRFRD     | 4                  |
| 9  | Direct Transient Response                         | DIRTRD     | 3                  |
| 10 | Modal Complex Eigenvalue Analysis                 | MDLCEAD    | 4                  |
| 11 | Modal Frequency and Random Response               | MDLFRD     | 6                  |
| 12 | Modal Transient Response                          | MDLTRD     | 5                  |
| 13 | Normal Modes Analysis with Differential Stiffness | NMDSTIF    | 6                  |
| 14 | Static Analysis with Cyclic Symmetry              | CYCSTAT    | 6                  |
| 15 | Normal Modes Analysis with Cyclic Symmetry        | CYCMODES   | 6                  |
|    | HEAT Rigid Formats                                |            |                    |
| 1  | Static Heat Transfer                              | HSTAT      | 4                  |
| 3  | Nonlinear Static Heat Transfer                    | HNLIN      | 3                  |
| 9  | Transient Heat Transfer                           | HTRD       | 1                  |
|    | AERO Rigid Format                                 |            |                    |
| 10 | Modal Flutter Analysis                            | FSUBSON    | 4                  |
|    | Direct Matrix Abstraction Program                 |            |                    |
|    | DMAP                                              | DMAP       | See Remark 5       |

- For details on error messages for the  $i^{\text{th}}$  Displacement Rigid Format see section 3.(i + 1) User's Manual. The Heat and Aero Rigid Formats follow these.
- The message number, a, may be any integer for DMAP messages.
- The third parameter is not currently used.

## UTILITY MODULES

I. NAME: PVEC (Substructure Analysis Partitioning Vector Data Generator)

II. PURPOSE: Generates a table similar to USET for use in Substructure Analysis.

III. DMAP CALLING SEQUENCE:

PVEC20 I01,I02,---,I20,GEØM4 / Ø1,Ø2,Ø3 / V,N,ØPT1 / V,N,ØPT2 / V,N,P01 / ---- / V,N,P20 \$

IV. INPUT DATA BLOCKS:

Iii, ii=01,20 - Table data blocks generated by GP4 in a Phase I Substructure Analysis execution. Up to twenty (20) substructures may be handled simultaneously. The inputs may be purged if either the substructure is absent or if it is identical to a previously appearing substructure.

GEØM4 - Preface output containing the coupling data extracted from the user's SAME and NØSAME bulk data cards.

V. OUTPUT DATA BLOCKS:

Ø1 - A table similar to USET which can be used to generate partitioning vectors by using utility module VEC.

Ø2 - Reserved for future use (may not be purged).

Ø3 - Reserved for future use (may not be purged).

VI. PARAMETERS:

ØPT1 - Input, integer, default = 1 which indicates no pseudostructure map is to be printed. A value of -1 indicates that the printing of the map is desired.

ØPT2 - Input, integer, default = 1 which indicates coupling is to occur for points mentioned on user-supplied SAME cards. A value of -1 directs PVEC to generate additional coupling information for any points having identical external identifications given on the input data blocks Iii. This additional information is merged with the user-supplied SAME and NØSAME coupling data.

Pii, ii=01,20 - Input, integer, default = 0. The values of these parameters define the substructures in the analysis. For example, if P17 = 20 then the data on input data block I17 would be assumed to represent substructure number 20. Zero values mean that the substructure is not present. In this case Iii should be purged. Negative values imply that the substructure is identical to the immediately preceding substructure. For example, if P07 = -14, then the data for substructure number 14 would be found on I06 unless P06 < 0 in which case it would be on I05, etc. Obviously, P01 ≥ 0.

VII. REMARKS:

For user convenience, two alternate forms of the PVEC module have been defined. For two to five substructures the user may use PVEC05.

PVEC05 I01,I02,---,I05,GEØM4 / Ø1,Ø2,Ø3 / V,N,ØPT1 / V,N,ØPT2 / V,N,P1 / V,N,P2 / --- / V,N,P5 \$

## DIRECT MATRIX ABSTRACTION

Similarly, PVEC10 is available for two to ten substructures.

```
PVEC10 I01,I02,---,I10,GE0M4 / 01,02,03 / V,N,0PT1 / V,N,0PT2 / V,N,P1 / V,N,P2 /
 --- / V,N,P10 $
```

### VIII. EXAMPLE:

Consider four substructures having identification numbers 10, 20, 30 and 40. Substructure 30 is identical to substructure 20. Substructure Analysis Phase I runs have been made for substructures 10, 20 and 40 creating data blocks A10, A20 and A40 which have been brought in from user tapes. To generate the partitioning vector bit table VSET, use

```
PVEC05 A10,A20, ,A40, ,GE0M4 / VSET,02,03 / C,N,-1 / C,N,+1 / C,N,10 / C,N,20 /
 C,N,-30 / C,N,40 $
```

To generate the partitioning vector for substructure 20, use

```
PARAM // C,N,SUB / V,N,B / C,N,33 / C,N,2 $ 2=SECOND ONE
VEC VSET / E20 / C,N,BITID / C,N, / C,N, / V,N,B $
```

To generate the complete partitioning vector matrix, use

```
VEC VSET / MPV / C,N,COLUMNS / C,N,RIGHT / C,N, / C,N,4 $ 4=N0. SUBSTRUCTURES
```

## UTILITY MODULES

I. NAME: SCALAR (Convert matrix element to parameter)

II. PURPOSE: To extract a specified element from a matrix for use as a parameter.

III. DMAP CALLING SEQUENCE:

SCALAR A//V,Y,NRØW=1/V,N,NCØL=1/C,Y,VALUE \$

IV. INPUT DATA BLOCKS:

A - may be any type of matrix.

NOTE: If A is purged, value will be returned as (0.,0.).

V. OUTPUT DATA BLOCKS:

None

VI. PARAMETERS:

NRØW - Input-integer, default=1. Row number of element to be extracted from [A].

NCØL - Input-integer, default=1. Column identification of element.

VALUE - Output-complex-single precision, default=(0.,0.). Contents of element (NRØW,NCØL) in matrix [A].

## DIRECT MATRIX ABSTRACTION

- I. NAME: SEEMAT (Pictorial Matrix Printer)
- II. PURPOSE: Shows nonzero matrix elements on printer or plotter output positioned pictorially by row and column within the outlines of the matrix.
- III. DMAP CALLING SEQUENCE:  
SEEMAT M1,M2,M3,M4,M5 // C,N,{PRINT/PLØT} / V,N,PFILE / V,N,PACK / C,N,plotter /  
C,N,modeln1 / C,N,modelb1 / C,N,modeln2 / C,N,modelb2 /  
C,N,sizeX / C,N,sizeY \$
- IV. INPUT DATA BLOCKS:  
Matrix Data Blocks, any of which may be purged.
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS:
1. PRINT implies use of the system output file. (Any value other than PLØT implies PRINT.)  
  
PLØT implies use of one of the plotters. Either of the plotter tapes PLT1 or PLT2 will be used, depending on the type of plotter requested (see Section 4.1).  
  
The default value for the first parameter is PRINT.
  2. PFILE is the Plot File Number. (Used only if first parameter is PLØT.)  
  
Input/output variable integer parameter. Frame or sheet number. The value of this parameter will be incremented by one (1) for each frame (sheet) plotted by SEEMAT.  
  
The default value for the second parameter is 0.
  3. PACK is reserved for a future modification that will allow the representation of a nonzero block of the matrix with a single character.  
  
The default value for the third parameter is 100.
  4. Plotter Name - If the first parameter = PLØT, one of the plotter names must be selected from the following list. Additional information on plotters and the meaning of the symbols used below is given in Section 4. The associated model identifiers are specified with the next four parameters. Each plotter has a default model associated with it, as indicated by the underlined model identifier.  
  
The default value for the fourth parameter is SC.

# UTILITY MODULES

| Plotter Name | Model Identifiers                                                                                                                                                                                                                                                        |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BL           | $\left\{ \begin{array}{l} \text{LTE},30 \\ \text{STE},30 \end{array} \right\}$                                                                                                                                                                                           |
| EAI          | $\left\{ \begin{array}{l} 3500,30 \\ 3500,45 \end{array} \right\}$                                                                                                                                                                                                       |
| <u>SC</u>    | <u>4020,0</u>                                                                                                                                                                                                                                                            |
| CALCØMP      | $\left\{ \begin{array}{l} 765,205 \\ 765,210 \\ 765,105 \\ 765,110 \\ 763,205 \\ 763,210 \\ 763,105 \\ 763,110 \\ 565,205 \\ 565,210 \\ 565,105 \\ 565,110 \\ 565,305 \\ 565,310 \\ 563,205 \\ 563,210 \\ 563,105 \\ 563,110 \\ 563,305 \\ 563,310 \end{array} \right\}$ |
| DD           | <u>80,B</u>                                                                                                                                                                                                                                                              |
| NASTPLT      | $\left\{ \begin{array}{l} \text{M},0 \\ \text{T},0 \\ \text{D},0 \\ \text{M},1 \\ \text{T},1 \\ \text{D},1 \end{array} \right\}$                                                                                                                                         |

5. The parameter modeln1 is used to specify the first of the two model identifiers when it is an integer value. The default value for the fifth parameter is 0.
6. The parameter modelb1 is used to specify the first of the two model identifiers when it is a BCD value. The default value for the sixth parameter is blank.
7. The parameter modeln2 is used to specify the second of the two model identifiers when it is an integer value. The default value for the seventh parameter is 0.
8. The parameter modelb2 is used to specify the second of the two model identifiers when it is a BCD value. The default value for the eighth parameter is blank.



## DIRECT MATRIX ABSTRACTION

9. The parameter `sizeX` specifies the size of the plotter surface x-dimension on those plotters for which it is appropriate (e.g., the `CALCOMP` plotter). The default value for `sizeX` is 30.0.
  10. The parameter `sizeY` specifies the size of the plotter surface y-dimension on those plotters for which it is appropriate (e.g., the `CALCOMP` plotter). The default value for `sizeY` is 30.0.
- VII. METHOD: The matrix is partitioned into blocks which can be printed on a single sheet of output paper or frame on the plotter selected. Only blocks containing nonzero elements will be output. Row and column indices are indicated. The user of this module is cautioned to make sure his line count limit is large enough. A default of 20,000 lines is provided by NASTRAN. This may be changed via the statement `MAXLINES=` value in the NASTRAN Case Control Deck. The transpose of the matrix is output.
- VIII. REMARKS:
1. If a plotter is used, the appropriate tape must be made available to NASTRAN.
  2. If a plotter is used, a `SAVE` instruction should be executed to update `PFILE`.
  3. The nonzero elements are indicated by asterisks (\*), except for diagonal elements of square matrices which are indicated by the letter `D`, and elements in the last row or column which are indicated by dollar signs (\$).
  4. The default model for any plotter is specified by omitting the last four parameters.
  5. When two of the last four parameters are used to specify model identifiers, the remaining two parameters should be specified as `C,N` only.
- IX. EXAMPLES:
1. Specify `CALCOMP 765,205` as follows:  

```
SEEMAT M1,M2,M3,M4,M5 // C,N,PL0T / V,N,PFILE / C,N / C,N,CALCOMP $
```
  2. Specify `EAI 3500,45` as follows:  

```
SEEMAT M1,M2,M3,M4,M5 // C,N,PL0T / V,N,PFILE / C,N / C,N,EAI / C,N,3500 / C,N / C,N,45 / C,N $
```
  3. Specify Benson Lehner `STE,30` as follows:  

```
SEEMAT M1,M2,M3,M4,M5 // C,N,PL0T / V,N,PFILE / C,N / C,N,BL / C,N / C,N,STE / C,N,30 / C,N $
```
  4. Specify the printer rather than a plotter as follows:  

```
SEEMAT M1,M2,M3,M4,M5 // $
```
  5. For additional examples see Section 5.4.8.

## UTILITY MODULES

- I. NAME: SETVAL (Set Values)
- II. PURPOSE: Set DMAP Parameter variable values equal to other DMAP Parameter variables or DMAP Parameter constants.
- III. DMAP CALLING SEQUENCE:
- ```
SETVAL // V,N,X1 / V,N,A1 /  
        V,N,X2 / V,N,A2 /  
        V,N,X3 / V,N,A3 /  
        V,N,X4 / V,N,A4 /  
        V,N,X5 / V,N,A5 $
```
- IV. INPUT DATA BLOCKS: None
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS:
- | | |
|--------------------|--|
| X1, X2, X3, X4, X5 | Output, integers, variables |
| A1, A2, A3, A4, A5 | Input, integers; default values = 1, variables or constants. |
- VII. METHOD: This module sets X1 = A1, X2 = A2, X3 = A3, X4 = A4, and X5 = A5. Only two parameters need be specified in the calling sequence (X1 and A1).
- VIII. REMARKS:
1. A SAVE instruction must immediately follow the SETVAL instruction if the output parameter values are to be subsequently used.
 2. See PARAM for an alternate method of defining parameter values.
 3. As an example, the statements
SETVAL // V,N,X1 / V,N,A1 / V,N,X2 / C,N,3 \$
SAVE X1,X2 \$
are equivalent to the statements
PARAM // C,N,ADD / V,N,X1 / V,N,A1 / C,N,0 \$
PARAM // C,N,NOP / V,N,X2=3 \$

DIRECT MATRIX ABSTRACTION

- I. NAME: TABPCH (Table Punch)
- II. PURPOSE: To punch NASTRAN tables onto DTI cards in order to allow transfer of data from one NASTRAN run to another, or to allow user postprocessing.
- III. DMAP CALLING SEQUENCE:
TABPCH TAB1,TAB2,TAB3,TAB4,TAB5 // C,N,A1 / C,N,A2 / C,N,A3 / C,N,A4 / C,N,A5 \$
- IV. INPUT DATA BLOCKS:
TAB1
TAB2
TAB3 Any NASTRAN Tables
TAB4
TAB5
- V. OUTPUT DATA BLOCKS:
None - All output is punched onto DTI cards.
- VI. PARAMETERS:
A1, A2, A3, A4, A5 -- Input - BCD - Defaults are 'AA', 'AB', 'AC', 'AD', 'AE'. These parameters are used to form the first two characters (columns 74, 75) of the continuation field for each table respectively.
- VII. REMARKS:
1. Any or all tables may be purged.
2. Integer and BCD characters will be punched onto single-field cards. Real numbers will be punched onto double-field cards. Their formats are I8, 2A4, E16.9.
3. Up to 99,999 cards may be punched per table.
4. Currently, twice the entire record must fit in open core.
5. Tables with 1 word BCD values (ELSETS) cannot be punched correctly.
- VIII. EXAMPLES:
TABPCH EST,,, // C,N,ES \$ will punch the EST onto cards with a continuation neumonic of +ES_{bbb}i (where i is the sequence number).

UTILITY MODULES

- I. NAME: TABPRT (Formatted Table Printer)
- II. PURPOSE: To print selected table data blocks with format for ease of reading.
- III. DMAP CALLING SEQUENCE:
TABPRT TDB // C,N,KEY / C,N,ØPT1 / C,N,ØPT2 \$
- IV. INPUT DATA BLOCKS:
TDB - Table Data Block from list given under X.
- V. ØUTPUT DATA BLOCKS: None
- VI. PARAMETERS:
1. KEY - Alphanumeric value, no default. Identifies the format to be used in printing the table. The allowable list is given under X.
 2. ØPT1 - Integer, default value = 0. If 0, no blank lines are written between entires. If ≠ 0, one blank line will be written between each entry.
 3. ØPT2 - Integer, default value = 0. Not used at present.
- VII. ØUTPUT:
The contents of the table are formatted and written on the system output file.
- VIII. NOTES:
1. The module returns in the event of any difficulty.
 2. The TABPT module can be used to print the contents of any data block.
- IX. EXAMPLES:
1. TABPRT CSTM // C,N,CSTM \$
 2. TABPRT GPL // C,N,GPL / C,N,1.\$

DIRECT MATRIX ABSTRACTION

X. MISCELLANEOUS

List of data blocks recognized by TABPRT (Rigid Format name used here. The actual DMAP name for the same or equivalent information is acceptable.)

<u>Data Block</u>	<u>Key (Value)</u>
BGPDT	BGPDT
CSTM	CSTM
EQDYN	EQDYN
EQEXIN	EQEXIN
GPCT	GPCT
GPDT	GPDT
GPL	GPL
GPLD	GPLD
GPTT	GPTT

UTILITY MODULES

- I. NAME: TABPT (Table Printer)
- II. PURPOSE: To print table data blocks (may be used for matrix data blocks if desired).
- III. DMAP CALLING SEQUENCE:
TABPT TAB1,TAB2,TAB3,TAB4,TAB5 // \$
- IV. INPUT DATA BLOCKS:
TAB1 -
TAB2 -
TAB3 - } Any NASTRAN data block.
TAB4 - }
TAB5 - }
- Note: Any or all input data blocks can be purged.
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS: None
- VII. REMARKS:
1. Each input data block is treated as a table and its contents are printed on the system output file via a prescribed format. Each word of the table is identified by the module as to type (real, BCD, integer) and an appropriate format is used.
2. The trailer data items for the table are also printed.
3. Purged input data blocks are not printed.
- VIII. EXAMPLES:
TABPT GEOM1,,, // \$
TABPT GEOM1,GEOM2,GEOM3,GEOM4,GEOM5 // \$

DIRECT MATRIX ABSTRACTION

- I. NAME: TIMETEST (Provides Timing Data)
- II. PURPOSE: To produce timing data for specific NASTRAN unit operations.
- III. DMAP CALLING SEQUENCE:
- TIMETEST /, / C,N,N / C,N,M / C,N,T / C,N,Ø1 / C,N,Ø2 \$
- IV. INPUT DATA BLOCKS: None
- V. OUTPUT DATA BLOCKS:
- FILE1
FILE2 Reserved for future implementation
- VI. PARAMETERS
- N - Outer Loop Index
- M - Inner Loop Index
- T - Data type to be processed
- Ø1 - TIMTST Routine to be processed
- Ø2 - Powers of two table for TIMTS1 option selection

See Section 4.127 of the NASTRAN Programmer's Manual for further description of the parameters.

VII. REMARKS

None.

VIII. EXAMPLES

TIMETEST /, / C,N,100 / C,N,100 / C,N,1 / C,N,2 \$

TIMETEST /, / C,N,10 / C,N,10 / C,N,3 / C,N,1 / C,N,127 \$

UTILITY MODULES

- I. NAME: VEC (Creates partitioning vector based on USET).
- II. PURPOSE: To create a partitioning vector for displacement method matrices using USET that may be used by Matrix Operation Modules MERGE and PARTN. This allows the user to split up long running modules such as SMP1.
- III. DMAP CALLING SEQUENCE:
- A. For matrices generated in Rigid Formats 1-6 or prior to module GKAD (or GKAM) in Rigid Formats 7-12:
VEC USET / V / C,N,SET / C,N,SET0 / C,N,SET1 / V,N,ID \$
- B. For matrices generated in Rigid Formats 7-12 after module GKAD (or GKAM):
VEC USETD / V / C,N,SET / C,N,SET0 / C,N,SET1 / V,N,ID \$
- IV. INPUT DATA BLOCKS:
- USET - U-set
or
USETD - U-set (Dynamics)
Note: U-set may not be missing and must fit into open core.
- V. OUTPUT DATA BLOCKS:
- V - Partitioning vector.
Note: 1. If all elements are in SET0 or SET1 then V will be purged.
2. V may not be purged prior to execution.
- VI. PARAMETERS:
- SET - Matrix set to be partitioned (Input ,BCD, no default.)
SET0 - Upper partition of SET (Input ,BCD, no default).
SET1 - Lower partition of SET (Input ,BCD, no default).
ID - Identification of bit position (see Remarks) (Input, integer, default = 0).
Note: 1. Legal parameter values are given in the table on page 5.3-17.
2. See Section 1.7.3 of the Programmer's Manual for a description of set notation or Section 3.3 of the Theoretical Manual.
- VII. REMARKS:
1. Parameters SET0 and SET1 must be a subset of the SET matrix parameter. A degree of freedom may not be in both subsets.
2. If desired, one of SET0 or SET1 but not both may be requested to be the complement of the other one by giving it a value of COMP.
3. If SET = BITID, the second and third parameters are ignored and the IDth bit position in USET (or USETD) is used. In this case, SET is assumed equal to G (or P) and SET0 will correspond to the zero's in the IDth position and SET1 will correspond to the non-zero's in the IDth position.

DIRECT MATRIX ABSTRACTION

VIII. EXAMPLES:

1. To partition $[K_{ff}]$ into a- and o- set based matrices, use

VEC USET / V / C,N,F / C,N, \emptyset / C,N,A \$

PARTN KFF,V, / K $\emptyset\emptyset$,KA \emptyset ,K \emptyset A,KAA \$

Note that the same thing can be done in one step by

UPARTN USET,KFF / K $\emptyset\emptyset$,KA \emptyset ,K \emptyset A,KAA / C,N,F / C,N, \emptyset / C,N,A \$

2. Example 1 could be accomplished by

VEC USET / V / C,N,F / C,N, \emptyset / C,N,C \emptyset MP \$

or

VEC USET / V / C,N,F / C,N,C \emptyset MP / C,N,A \$

3. Example 1 could be accomplished by

VEC USET / V / C,N,BITID / C,N,X / C,N,X / C,N,25 \$

DIRECT MATRIX ABSTRACTION

5.6 USER MODULES

<u>Module</u>	<u>Basic Function</u>	<u>Page</u>
DDR	User Dummy Module	5.6-2
DUMMØD1	Dummy Module-1	5.6-3
DUMMØD2	Dummy Module-2	5.6-4
DUMMØD3	Dummy Module-3	5.6-5
DUMMØD4	Dummy Module-4	
INPUTT3	Auxiliary Input File Processor	5.6-7
INPUTT4	Auxiliary Input File Processor	5.6-8
MØDA	User Dummy Module	5.6-9
MØDB	User Dummy Module	5.6-10
MØDC	User Dummy Module	5.6-11
ØUTPUT	Auxiliary Output File Processor	5.6-12
ØUTPUT4	Auxiliary Output File Processor	5.6-13
PARTVEC	User Dummy Module	5.6-14
XYPRNPLT	User Dummy Module	5.6-15

A number of modules have been placed in the NASTRAN system for which only dummy code exists. These modules are available to the user who wishes to create his own data blocks by reading tapes or data cards, generate his own output on the printer, punch or plotter, or perform his own matrix computations. The appropriate MPL information is presented for each such user module in this section. All necessary interfaces with the Executive System have been completed for these user modules. The procedures for implementing a user module are described in Section 2 of the Programmer's Manual.

DIRECT MATRIX ABSTRACTION

- I. NAME: DDR (User Dummy Module)
- II. PURPOSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (see REMARKS below)
DDR A/X/C,N,ABC/C,N,DEF/C,N,GHI \$
- IV. INPUT DATA BLOCKS: As desired by author of module.
- V. OUTPUT DATA BLOCKS: As desired by author of module.
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.
- VII. REMARKS:
This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs, as well as the number, type, and default values of the parameters, may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of the Programmer's Manual).

USER MODULES

- I. NAME: DUMMØD1 (Dummy Module - 1)*
- II. PURPØSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (see REMARKS)
DUMMØD1 I1,I2,I3,I4,I5,I6,I7,I8 /
Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
C,Y,P5=-1.0 / C,N,-1.0 /
C,Y,P7=ABCDEFGH /
C,Y,P8=-1.0D0 /
C,Y,P9=(-1.0,-1.0) /
C,Y,P10=(-1.0D0,-1.0D0) \$
- IV. INPUT DATA BLØCKS: As desired by author of module.
- V. ØUTPUT DATA BLØCKS: As desired by author of module.
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.
- VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

*The delivery version of NASTRAN contains a DUMMØD1 module which is used to compute timing constants for the various machines on which the program runs.

DIRECT MATRIX ABSTRACTION

- I. NAME: DUMMØD2 (Dummy Module - 2)
- II. PURPØSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (see REMARKS)
DUMMØD2 I1,I2,I3,I4,I5,I6,I7,I8 /
Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
C,Y,P5=-1.0 / C,N,-1.0 /
C,Y,P7=ABCDEFGH /
C,Y,P8=-1.000 /
C,Y,P9=(-1.0,-1.0) /
C,Y,P10=(-1.000,-1.000) \$
- IV. INPUT DATA BLØCKS: As desired by author of module.
- V. ØUTPUT DATA BLØCKS: As desired by author of module.
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.
- VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

USER MODULES

- I. NAME: DUMMØD3 (Dummy Module - 3)
- II. PURPØSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (see REMARKS)
DUMMØD3 I1,I2,I3,I4,I5,I6,I7,I8 /
Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
C,Y,P5=-1.0 / C,N,-1.0 /
C,Y,P7=ABCDEFGH /
C,Y,P8=-1.0D0 /
C,Y,P9=(-1.0,-1.0) /
C,Y,P10=(-1.0D0,-1.0D0) \$
- IV. INPUT DATA BLØCKS: As desired by author of module.
- V. ØUTPUT DATA BLØCKS: As desired by author of module.
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.
- VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

DIRECT MATRIX ABSTRACTION

- I. NAME: DUMMØD4 (Dummy Module - 4)
- II. PURPOSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (see REMARKS)
DUMMØD4 I1,I2,I3,I4,I5,I6,I7,I8 /
Ø1,Ø2,Ø3,Ø4,Ø5,Ø6,Ø7,Ø8 /
C,N,-1 / V,Y,P2=-1 / V,N,P3=-1 / C,Y,P4=-1 /
C,Y,P5=-1.0 / C,N,-1.0 /
C,Y,P7=ABCDEFGH /
C,Y,P8=-1.000 /
C,Y,P9=(-1.0,-1.0) /
C,Y,P10=(-1.000,-1.000) \$
- IV. INPUT DATA BLOCKS: As desired by author of module.
- V. OUTPUT DATA BLOCKS: As desired by author of module.
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the default values shown in the calling sequence above.
- VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

USER MODULES

- I. NAME: INPUTT3 (Auxiliary Input File Processor)
- II. PURPOSE: A user-written module to generate data block(s) and parameter(s) based on input data read by the module itself, or on parameter values or Input Data Blocks generated by NASTRAN, or by any combination of these.
- III. DMAP CALLING SEQUENCE:
INPUTT3 I1,I2,I3,I4,I5 / 01,02,03,04,05 / C,N,a / C,N,b / C,N,c \$
- IV. INPUT DATA BLOCKS: Any or all of the inputs may be purged according to the user-writer's design.
- V. OUTPUT DATA BLOCKS: May be tables or matrices depending on the user-writer's design; may or may not be purged.
- VI. PARAMETERS: May be used as desired by the user-writer. Type is integer with default values of a=-1, b=0, c=0. If parameter is to be output from module, the form C,N,_ must be changed in the above example to V,N,NAME or some other form capable of being output.
- VII. REMARKS: This module has been provided for the NASTRAN user who wishes to process his own data cards. Data block(s) created must be compatible with any subsequent module(s) using them as input. The number of input and output data blocks, as well as the number, type and default values of the parameters, may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (See Section 2 of Programmer's Manual).

DIRECT MATRIX ABSTRACTION

- I. NAME: INPUTT4 (Auxiliary Input File Processor)
- II. PURPOSE: A user-written module to generate data block(s) and parameter(s) based on input data read by the module itself, or on parameter values or Input Data Blocks generated by NASTRAN, or by any combination of these.
- III. DMAP CALLING SEQUENCE:
INPUTT4 I1,I2,I3,I4,I5 / 01,02,03,04,05 / C,N,a / C,N,b / C,N,c \$
- IV. INPUT DATA BLOCKS: Any or all of the inputs may be purged according to the user-writer's design.
- V. OUTPUT DATA BLOCKS: May be tables or matrices depending on the user-writer's design; may or may not be purged.
- VI. PARAMETERS: May be used as desired by the user-writer. Type is integer with default values of a=-1, b=0, c=0. If parameter is to be output from module, the form C,N,_ must be changed in the above example to V,N,NAME or some other form capable of being output.
- VII. REMARKS: This module has been provided for the NASTRAN user who wishes to process his own data cards. Data block(s) created must be compatible with any subsequent module(s) using them as input. The number of input and output data blocks, as well as the number, type and default values of the parameters, may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (See Section 2 of Programmer's Manual).

USER MODULES

- I. NAME: MØDA (User Dummy Module)
- II. PURPOSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (See REMARKS below)
MØDA / W,X,Y,Z / C,N,0.0 / C,N,0.0 / C,N,0.0 / C,N,0.0 / C,N,0.0 / C,N,0 /
C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0.0 / C,N,0 / C,N,0 \$
- IV. INPUT DATA BLOCKS: None
- V. OUTPUT DATA BLOCKS: As desired by author of module.
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.
- VII. REMARKS: This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

DIRECT MATRIX ABSTRACTION

- I. NAME: MØDB (User Dummy Module)
- II. PURPOSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (See REMARKS below)
MØDB A,B,C / W,X,Y,Z / C,N,1.0 / C,N,1.0 / C,N,1.0 / C,N,1.0 / C,N,0 / C,N,0 / C,N,0 /
C,N,1.0 / C,N,0 / C,N,0 / C,N,0 \$
- IV. INPUT DATA BLOCKS: As desired by author of module.
- V. OUTPUT DATA BLOCKS: As desired by author of module.
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.
- VII. REMARKS:
This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

USER MODULES

- I. NAME: MØDC (User Dummy Module)
- II. PURPOSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (See REMARKS below)
MØDC A,B // C,N,-1 \$
- IV. INPUT DATA BLOCKS: As desired by author of module.
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the constants shown in the calling sequence shown above.
- VII. REMARKS:
This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

DIRECT MATRIX ABSTRACTION

- I. NAME: ØUTPUT (Auxiliary Output File Processor)
- II. PURPOSE: A user-written module to generate printer, plotter or punch output.
- III. DMAP CALLING SEQUENCE: (see remark under METHOD)
ØUTPUT IN // C,Y,P=-1 \$
- IV. INPUT DATA BLOCKS:
IN - Contains any desired information which the module extracts and writes on the system output file, punch, or either of the two plotters. May be purged.
- V. ØUTPUT DATA BLOCKS: None
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. Type is integer with MPL default value of -1 as shown above.
- VII. METHOD: This module has been provided for the user of NASTRAN who may wish to process his own output. The number of inputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

USER MODULES

- I. NAME: ØUTPUT4 (Auxiliary Output File Processor)
- II. PURPOSE: A user-written module to generate printer, plotter or punch output.
- III. DMAP CALLING SEQUENCE: (see remark under METHOD)
ØUTPUT4 IN1,IN2,IN3,IN4,IN5 // V,N,P1=-1 / V,N,P2=-1 \$
- IV. INPUT DATA BLOCKS:
INi - Contains any desired information which the module extracts and writes on the system output file, punch, or either of the two plotters. May be purged.
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. Type is integer with MPL default value of -1 as shown above.
- VII. METHOD: This module has been provided for the user of NASTRAN who may wish to process his own output. The number of inputs as well as the number, type, and default values of parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

DIRECT MATRIX ABSTRACTION

- I. NAME: PARTVEC (User Dummy Module)
- II. PURPOSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (See REMARKS below)
PARTVEC I01,I02,---,I20,I21 / 01,02,03 / V,N,P1=0 / V,N,P2=0 / --- / V,N,P22=0 \$
- IV. INPUT DATA BLOCKS: As desired by author of module.
- V. OUTPUT DATA BLOCKS: As desired by author of module.
- VI. PARAMETERS: Parameters may be used as desired by the author of the module. The parameter types are indicated by the values shown in the calling sequence shown above.
- VII. REMARKS:
This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMPLBD (see Section 2 of Programmer's Manual).

USER MODULES

- I. NAME: XYPRNPLT (User Dummy Module)
- II. PURPOSE: Can be used for any desired purpose.
- III. DMAP CALLING SEQUENCE: (see REMARKS below)
XYPRNPLT A// \$
- IV. INPUT DATA BLOCKS: As desired by the author of module.
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS: None
- VII. REMARKS:
This module has been provided for the user of NASTRAN who may wish to include a module of his own design into the system. The number of inputs and outputs as well as the number, type, and default values of the parameters may be changed by changing the Module Properties List (MPL) in Block Data Program XMP LBD (see Section of Programmer's Manual).

DIRECT MATRIX ABSTRACTION

5.7 EXECUTIVE OPERATION MODULES

<u>Module</u>	<u>Basic Function</u>	<u>Page</u>
BEGIN	Always first in DMAP; begin DMAP program	5.7-2
CHKPNT	Write data blocks on checkpoint tape if checkpointing	5.7-3
CØND	Conditional forward jump	5.7-4
END	Always last in DMAP; terminates DMAP execution	5.7-5
EQUIV	Assign another name to a data block	5.7-6
EXIT	Conditional DMAP termination	5.7-7
FILE	Defines special data block characteristics to DMAP compiler	5.7-8
JUMP	Unconditional forward jump	5.7-9
LABEL	Defines DMAP location	5.7-10
PURGE	Conditional data block elimination	5.7-11
REPT	Repeat a series of DMAP instructions	5.7-12
SAVE	Save value of output parameter	5.7-13

All modules classified as Executive Operation Modules are individually described in this section. Additional discussions concerning the interaction of the Executive Modules with themselves and with the NASTRAN Executive System are contained in Section 5.2.3.

DIRECT MATRIX ABSTRACTION

- I. NAME: BEGIN (Begin DMAP program)
- II. PURPOSE: BEGIN Is a declarative DMAP instruction which denotes the beginning of a DMAP program.
- III. DMAP CALLING SEQUENCE:
BEGIN \$
- IV. REMARKS:
 - 1. The BEGIN card is required when selecting APP DMAP in the Executive Control Deck and must be followed by DMAP instructions up to and including the END card.
 - 2. BEGIN is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.

EXECUTIVE OPERATION MODULES

I. NAME: CHPNT (Checkpoint)

II. PURPOSE: Causes data blocks to be written on the New Problem Tape (NPTP) to enable the problem to be restarted with a minimum of redundant processing.

III. DMAP CALLING SEQUENCE:

CHKPNT D1,D2,...,DN \$

where D1,D2,...,DN ($N \geq 1$) are data blocks to be copied onto the problem tape for use in restarting problem.

IV. RULES:

1. A data block to be checkpointed must have been referenced in a previous PURGE, EQUIV or functional module instruction.
2. CHPNT cannot be the first instruction of a DMAP loop.
3. Data Blocks generated by the Input File Processor (including DMI's and DTI's) should not be checkpointed since they are always regenerated on restart.
4. Checkpointing only takes place when a New Problem Tape (NPTP) is set up and the Executive Control Card CHPNT YES appears in the Executive Control Deck. Otherwise, the CHPNT instructions are ignored.
5. For each data block that is successfully checkpointed, a card of the restart dictionary is punched which gives the critical data for the data block as it exists on the Problem Tape.
6. For data blocks that have been purged or equivalenced, an entry is made in the restart dictionary to this effect. In these cases data blocks are not written on the Problem Tape.

DIRECT MATRIX ABSTRACTION

I. NAME: CØND (Conditional Transfer)

II. PURPØSE: To alter the normal order of execution of DMAP modules by conditionally transferring program control to a specified location in the DMAP program.

III. DMAP CALLING SEQUENCE:

CØND n,V \$

where:

1. n is a BCD label name specifying the location where control is to be transferred. (See the LABEL instruction.)
2. V is a BCD name of a variable parameter whose value indicates whether or not to execute the transfer. If $V < 0$ the transfer is executed.

IV. EXAMPLE:

BEGIN \$

.

.

.

CØND L1,K \$

MØDULE1 A/B/V,Y,P1 \$

.

.

.

LABEL L1 \$

MØDULEN X/Y \$

.

.

.

END \$

If $K \geq 0$, MØDULE1 is executed. If $K < 0$ control is transferred to the label L1 and MØDULEN is executed.

V. REMARKS:

Only forward transfers are allowed. See the REPT instruction for backward transfers.

EXECUTIVE OPERATION MODULES

- I. NAME: END (End DMAP Program)
- II. PURPOSE: Denotes the end of a DMAP program.
- III. DMAP CALLING SEQUENCE:
END \$
- IV. NOTES:
 - 1. The END instruction also acts as an implied EXIT instruction.
 - 2. The END card is required whenever the analyst selects APP DMAP in his Executive Control Deck.

DIRECT MATRIX ABSTRACTION

- I. NAME: EQUIV (Data Block Name Equivalence)
- II. PURPOSE: To attach one or more equivalent (alias) data block names to an existing data block so that the data block can be referenced by several equivalent names.
- III. DMAP CALLING SEQUENCE:
EQUIV DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB \$

Note: The number of data block names (DBNij) prior to each parameter (PARMj) and the number of such groups in a particular calling sequence are variable.
- IV. INPUT DATA BLOCKS:
DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence. The 1st data block name in each group (DBN1A and DBN1B in the examples above) is known as the primary data block and the 2nd, etc. data block names become equivalent to the primary (depending on the associated parameter value). These equivalenced data blocks are known as secondary data blocks.
- V. OUTPUT DATA BLOCKS: (None specified or permitted)
- VI. PARAMETERS:
PARMA, etc. - One required for each set of data block names.
- VII. METHOD: The data block names in each group are made equivalent if the value of the associated parameter is < 0 . If a number of data blocks are already equivalenced and the parameter value is ≥ 0 , the equivalence is broken and the data block names again become unique. Also, this unequivalence operation causes the status of all the secondary data blocks to be not generated. If the data blocks are not equivalenced and the parameter value is ≥ 0 , no action is taken.
- VIII. RULES:
 1. The primary data block must be output from a previous functional module.
 2. The primary data block must be referenced in the immediately preceding functional module and/or in a subsequent functional module.

EXECUTIVE OPERATION MODULES

I. NAME: EXIT (Terminate DMAP program)

II. PURPOSE: To conditionally terminate the execution of the DMAP program.

III. DMAP CALLING SEQUENCE:

EXIT c \$

where c is an integer constant which specifies the number of times the instruction is to be ignored before terminating the program. If c = 0 the calling sequence may be shortened to EXIT \$.

IV. EXAMPLE:

```
      BEGIN $
      .
      .
      .
      LABEL L1 $
      MODULE A/B/V,Y,P1 $
      .
      .
      .
      EXIT 3 $
      REPT L1,3 $
      .
      .
      .
      END $
```

DMAP loop {

V. REMARKS:

1. The EXIT instruction will be executed the third time the loop is repeated (i.e., the instructions within the loop will be executed four times).
2. EXIT may appear anywhere within the DMAP sequence.

DIRECT MATRIX ABSTRACTION

- I. NAME: FILE (File Allocation Aide)
- II. PURPOSE: To inform the File Allocator (see Section 4.9 of the Programmer's Manual) of any special characteristics of a data block.

III. DMAP CALLING SEQUENCE:

FILE A=a1,a2...a α / B=b1,b2...b β / / Z=z1,z2...z ω \$

where:

A,B...Z are the names of the data blocks possessing special characteristics.

a1...a α ,b1...b β ...z1...z ω are the special characteristics from the list below.

The allowable special characteristics are:

1. SAVE - Indicates data block is to be saved for possible looping in DMAP program.
2. APPEND - Output data blocks which are generated within a DMAP loop are rewritten during each pass through the loop, unless the data block is declared APPEND in a FILE statement. The APPEND declaration allows a module to add information to a data block on successive passes through a DMAP loop.
3. TAPE - Indicates that data block is to be written on a physical tape if a physical tape is available.

Notes:

1. Data blocks created by the NASTRAN preface may not appear in FILE declarations.
2. Symbolic DMAP sequences which explain the use of the FILE instruction are given in Section 5.2.3.1.
3. FILE is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.
4. A data block name may appear only once in all FILE statements; otherwise the first appearance will determine all special characteristics applied to the data block.

EXECUTIVE OPERATION MODULE

I. NAME: JUMP (Unconditional Transfer)

II. PURPOSE: To alter the normal order of execution of DMAP modules by unconditionally transferring program control to a specified location in the DMAP program. The normal order of execution of DMAP modules is the order of occurrence of the modules as DMAP instructions in the DMAP program.

III. DMAP CALLING SEQUENCE:

JUMP n \$

where n is a BCD name appearing on a LABEL instruction which specifies where control is to be transferred.

IV. Remarks:

Jumps must be forward in the DMAP sequence. See the REPT instruction for backward jumps.

DIRECT MATRIX ABSTRACTION

I. NAME: LABEL (DMAP Location)

II. PURPOSE: To label a location in the DMAP program so that the location may be referenced by the DMAP instructions JUMP, COND and REPT.

III. DMAP CALLING SEQUENCE:

LABEL n \$

where n is a BCD name.

IV. Remarks:

1. The LABEL instruction is inserted just ahead of the DMAP instruction to be executed when transfer of control is made to the label.
2. LABEL is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.

EXECUTIVE OPERATION MODULE

I. NAME: PURGE (Explicit Data Block Purge)

II. PURPOSE: To flag a data block so that it will not be assigned to a physical file.

III. DMAP CALLING SEQUENCE:

PURGE DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB \$

Note: The number of data block names (DBN_{ij}) prior to each parameter ($PARM_j$) and the number of groups of data block names and parameters in a particular calling sequence is variable.

IV. INPUT DATA BLOCKS:

DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence.

V. OUTPUT DATA BLOCKS: (None specified or permitted)

VI. PARAMETERS:

PARMA, etc. - One required for each group of data block names.

VII. METHOD: The data blocks in a group are purged if the value of the associated parameter is < 0 . If a data block is already purged and the parameter value is ≥ 0 , the purged data block is unpurged so that it may be subsequently reallocated. If the data block is not purged and the parameter value is ≥ 0 , no action is taken.

DIRECT MATRIX ABSTRACTION

I. NAME: REPT (Repeat)

II. PURPOSE: To repeat a group of DMAP instructions a specified number of times.

III. DMAP CALLING SEQUENCE:

REPT n,c \$

where:

1. n is a BCD name which specifies the name of a label which marks the beginning of the group of DMAP instructions to be repeated. (See LABEL instruction).
2. c is an integer constant which specifies the number of times to repeat the instructions.

IV. EXAMPLE:

BEGIN \$

.

.

.

LABEL L1 \$

MODULE1 A/B/V,Y,P1 \$

.

.

.

MODULEN B/C/V,Y,PN \$

REPT L1,3 \$

.

.

.

END \$

V. REMARKS:

1. The instructions MODULE1 to MODULEN will be repeated three times (i.e., executed four times) in the above example.
2. REPT is placed at the end of the group of instructions to be repeated.
3. The constant, c, may not be a parameter name.

EXECUTIVE OPERATION MODULE

- I. NAME: SAVE (Save Variable Parameter Values)
- II. PURPOSE: To specify which variable parameter values are to be saved from the preceding functional module DMAP instruction for use by subsequent modules.
- III. DMAP CALLING SEQUENCE:
SAVE V1,V2,...,VN \$

where the V1,V2,...,VN ($N > 0$) are the BCD names of some or all of the variable parameters which appear in the immediately preceding Functional Module DMAP instruction.
- IV. REMARKS:
A SAVE instruction must immediately follow the functional module instruction wherein the parameters being saved are generated.

DIRECT MATRIX ABSTRACTION

5.8 EXAMPLES

In order to facilitate the use of DMAP, several examples are provided in this section. The user is urged to study these examples both from the viewpoint of performing a sequence of matrix operations and that of a DMAP flow.

5.8.1 DMAP Example

Objective

1. Print the contents of table data block A.
2. Print matrix data blocks B,C, and D.
3. Print values of parameters P1 and P2.
4. Set parameter P3 equal to -7.

```
BEGIN      $
TABPT      A,,, // $
MATPRN     B,C,D,, // $
PRTPARM    // C,N,0 / C,N,P1 $
PRTPARM    // C,N,0 / C,N,P2 $
PARAM      // C,N,NØP / V,N,P3=-7 $
END        $
```

Remarks:

To be a practical example, a restart situation is assumed. The user is cautioned to remember to reenter at DMAP instruction 2 by changing the last reentry point in the restart dictionary.

DIRECT MATRIX ABSTRACTION

5.8.2 DMAP Example

Let the constrained stiffness matrix $[K_{\ell\ell}]$ and the load vector $\{P_\ell\}$ be defined by means of DMI bulk data cards. The following DMAP sequence will perform the series of matrix operations

$$\begin{aligned}\{u_1\} &= [K_{\ell\ell}]^{-1} \{P_\ell\} \\ \{r\} &= [K_{\ell\ell}] \{u_1\} - \{P_\ell\} \\ \{\delta u\} &= [K_{\ell\ell}]^{-1} \{r\} \\ \{u_2\} &= \{u_1\} + \{\delta u\} \\ \text{Print } \{u_2\}\end{aligned}$$

```
BEGIN      $
SOLVE     KLL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 $
MPYAD     KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 $
SOLVE     KLL,R / DU / C,N,1 $
ADD       U1,DU / U2 $
MATPRN    U2,,,, // $
END       $
```

Remarks:

1. $[K_{\ell\ell}]$ is assumed symmetric.
2. In the example above, KLL will be decomposed twice. A more efficient DMAP sequence, which requires only a single decomposition for this problem, is given below.

```
BEGIN      $
DECOMP    KLL / LLL,ULL $
FBS       LLL,ULL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 $
MPYAD     KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 $
FBS       LLL,ULL,R / DU $
ADD       U1,DU / U2 $
MATPRN    U2,,,, // $
END       $
```

EXAMPLES

5.8.3 DMAP Example to Use the Structure Plotter to Generate Undeformed Plots of the Structural Model

```

BEGIN      $
GP1        GEØM1,GEØM2, / GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL / V,N,LUSET / V,N,NØCSTM / V,N,NØGPDT $
SAVE       LUSET $
GP2        GEØM2,EQEXIN / ECT $
PLTSET     PCDB,EQEXIN,ECT / PLTSETX,PLTPAR,GPSETS,ELSETS / V,N,NSIL / V,N,NPSET $
SAVE       NPSET,NSIL $
PRMSG      PLTSETX // $
PARAM      // C,N,NØP / V,N,PLTFLG=1 $
PARAM      // C,N,NØP / V,N,PFILE=0 $
CØND       P1,NPSET $
PLØT       PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,, / PLØTX1 / V,N,NSIL / V,N,LUSET /
           V,N,NPSET / V,N,PLTFLG / V,N,PFILE $
SAVE       NPSET,PLTFLG,PFILE $
PRMSG      PLØTX1 // $
LABEL      P1 $
PRTPARM     // C,N,0 $
END         $

```

Remarks:

1. GEØM1, GEØM2, PCDB and CASECC are generated by the Input File Processor.
2. PRTPARM is used to print all current variable parameter values.
3. This DMAP sequence contains several structurally oriented modules. This sequence of DMAP instructions is essentially identical with the section of each rigid format associated with the operation of the Structure Plot Request Packet of the Case Control Deck (contained in data block PCDB).

DIRECT MATRIX ABSTRACTION

5.8.4 Example of DMAP to Print Eigenvectors Associated with any of the Modal Formulation Rigid Formats

```
BEGIN      $
ØFP        LAMA,ØEIGS,,,, // $
SDR1       USET,,PHIA,,,GØ,GM,,KFS,, / PHIG,,QG / C,N,1 / C,N,REIG $
SDR2       CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,QG,PHIG,EST, / , ØQG1,ØPHIG,ØES1,ØEF1, /
           C,N,REIG $
ØFP        ØPHIG,ØQG1,ØEF1,ØES1,, // $
END        $
```

Remarks:

1. A restart from a successfully executed modal formulation is assumed.
2. This DMAP sequence contains several structurally oriented modules.

EXAMPLES

5.8.5 Example of DMAP Using a User-written Module

As an example of how a user might perform matrix operations of his own design, the following DMAP is provided. Functional modules MØDA, MØDB, and MØDC are assumed to be written by the user and added to the NASTRAN system, replacing dummy modules with the same names. A brief explanation of a problem for which this DMAP is applicable is given.

```

1  BEGIN      $
2  PARAM      // C,N,NØP / V,N,TRUE=-1 $
3  PARAM      // C,N,NØP / V,N,FALSE=+1 $
4  MØDA       / X,Y,DB,A / V,N,BETA=0.0 / V,N,SIGMA=1.0 / V,N,FW=0.0 / V,N,SW=0.0 /
              V,N,ETAINF=5.0 / V,N,M=100 / C,N,0 / C,N,0 / C,N,0 / V,N,ICØNV=0 /
              V,N,ZCØNV=1.0E-4 / V,N,ITMAX=10 / C,N,0 $
5  SAVE       BETA,SIGMA,FW,SW,ETAINF,M,ICØNV,ZCØNV,ITMAX $
6  LABEL      TØP $
7  FILE       A=SAVE / DB=SAVE $
8  SØLVE      A,DB / DY / C,N,0 / C,N,1 / C,N,1 / C,N,1 $
9  EQUIV      X,XX / FALSE / Y,YY / FALSE $
10 MØDB       X,Y,DY / XX,YY,DBB,AA / V,N,BETA / V,N,SIGMA / V,N,FW / V,N,SW / V,N,M /
              C,N,0 / V,N,ICØNV / V,N,ZCØNV / C,N,0 / V,N,DØNE=1 / V,N,DIVERGED=1 $
11 SAVE       DØNE,DIVERGED $
12 CØND       QUIT,DIVERGED $
13 CØND       ØUT,DØNE $
14 EQUIV      XX,X / TRUE / YY,Y / TRUE / DBB,DB / TRUE / AA,A / TRUE $
15 CØND       QUIT,ITMAX $
16 REPT       TØP,1000 $
17 PRTPARM    // C,N,-1 / C,N,DMAP $
18 EXIT       $
19 LABEL      ØUT $
20 MØDC       X,Y // $
21 EXIT       $
22 LABEL      QUIT $
23 PRTPARM    // C,N,-2 / C,N,DMAP $
24 EXIT       $
25 END        $

```

The above DMAP sequence is designed to solve an iteration problem where {x} is the set of independent variable values on which the discretized solution {y(x)} is defined. Let the discrete values of {y(x)} measured at {x} be called {y}. An iteration sequence

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$$\{y\}^{i+1} = \{y\}^i + [A(\{y\}^i, \{x\})]^{-1} \{\delta b(\{y\}^i, \{x\})\}$$

is to be performed where $[A]$ and $\{\delta b\}$ are computable functions of $\{y\}$ and $\{x\}$. A convergence-divergence criterion is assumed known. It is also assumed that the independent variable distribution $\{x\}$ may be modified as the solution proceeds. A brief description of the significant DMAP instructions is given below:

- 4 Initialization of all parameters and output data blocks. This module is assumed to be written by the user.
- 7 Prevents file allocator from dropping A and DB.
- 8 Compute $\{\delta y\} = [A]^{-1} \{\delta b\}$
- 9 Break equivalences.
- 10 Iterate to obtain new $\{x\}$, $\{y\}$, $\{\delta b\}$, $[A]$; test convergence and set parameters DONE and DIVERGED. This module is assumed to be written by the user.
- 14 The new $\{x\}$, $\{y\}$, $\{\delta b\}$, $[A]$ are established as current by replacing the old values.
- 20 Prints out the converged solutions $\{x\}$ and $\{y\}$. This module is assumed to be written by the user.

EXAMPLES

5.8.6 DMAP ALTER Package for Using a User-Written Auxiliary Input File Processor

```

ALTER      1
INPUT      GEØM1,,, / G1,,G4, / C,N,3 $
PARAM      // C,N,NØP / V,N,TRUE=-1 $
EQUIV      G1,GEØM1 / TRUE / G4,GEØM4 / TRUE $
CØND       LBLXXX,TRUE $
TABPT      G1,G4,,, // $
LABEL      LBLXXX $
ENDALTER

```

Remarks:

1. This is an ALTER package that could be used by any Rigid Format.
2. The last three instructions are needed to avoid violating the Equivalence rule that a primary data block name must be referenced in a subsequent functional module. A way to avoid using these three instructions is to move the PARAM ahead of INPUT, in which case the EQUIV immediately follows the module in which the primary data blocks are output. In this case the ALTER package becomes

```

ALTER      1
PARAM      // C,N,NØP / V,N,TRUE=-1 $
INPUT      GEØM1,,, / G1,,G4, / C,N,3 $
EQUIV      G1,GEØM1 / TRUE / G4,GEØM4 / TRUE $
ENDALTER

```

3. It is assumed that a user-written module INPUT exists which reads data block GEØM1 (created by the Input File Processor of the NASTRAN Preface) and creates data blocks G1 and G4. It is then desired to use G1 and G4 in place of GEØM1 and GEØM4, the data blocks normally created by the NASTRAN Preface.
4. ALTER is described in Section 2.2.

DIRECT MATRIX ABSTRACTION

5.8.7 DMAP to Perform Real Eigenvalue Analysis Using Direct Input Matrices

```

BEGIN      $
READ       KTEST,MTEST,,,DYNAMICS,,CASECC / LAMA,PHIA,MI,ØEIGS / C,N,MØDES / V,N,NE $
ØFP        LAMA,ØEIGS,,,, // $
MATPRN     PHIA,,,, // $
END        $

```

Notes:

1. The echo of a test problem bulk data deck for the preceding DMAP sequence follows.

	1	..	2	..	3	..	4	..	5	..	6	..	7	..	8	..	9	..	10	.
DMI	KTEST	0			6		1		2				4		4					
DMI	KTEST	1			1			200.0	-100.0											
DMI	KTEST	2			1			-100.0	200.0			-100.0								
DMI	KTEST	3			2			-100.0	200.0			-100.0								
DMI	KTEST	4			3			-100.0	200.0											
DMI	MTEST	0			6		1		2				4		4					
DMI	MTEST	1			1			1.0												
DMI	MTEST	2			2			1.0												
DMI	MTEST	3			3			1.0												
DMI	MTEST	4			4			1.0												
EIGR	1		INV		.0		2.5		2		2								+1	
+1	MAX																			

2. Data blocks DYNAMICS and CASECC are generated by the NASTRAN Preface (Input File Processor) and contain the eigenvalue extraction data from the EIGR card and the eigenvalue method selection data extracted from the METHODØD card in the Case Control Deck.
3. Data blocks KTEST and MTEST are generated by the NASTRAN Preface (Input File Processor) from the DMI bulk data cards.
4. Data block MI is the modal mass matrix, which is not used in this DMAP subsequent to READ, but which must appear as an output in READ. Parameter NE is an output parameter whose value is the number of eigenvalues extracted. If none are found NE will be set to -1.

Alternate DMAP to perform real eigenvalue analysis using Direct Input Matrices where the degrees of freedom are associated with grid points.

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```

BEGIN      $
GP1        GEØM1,GEØM2, / GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL / V,N,LUSET / C,N,O / C,N,O $
SAVE       LUSET $
GP4        CASECC,,EQEXIN,SIL,GPDT,BGPDT,CSTM / ,,USET, / V,N,LUSET / C,N,O / C,N,O /
C,N,O / C,N,O / C,N,O / C,N,O / C,N,O / C,N,O / C,N,O / C,N,O $
DPD        DYNAMICS,GPL,SIL,USET / GPLD,SILD,USETD,,,,,EED,EQDYN / V,N,LUSET / C,N,O /
C,N,O / C,N,O / C,N,O / C,N,O / C,N,O / C,N,O / V,N,NØEED / C,N,O / C,N,O $
SAVE       NØEED $
CØND       E1,NØEED $
READ       KTEST,MTEST,,EED,,CASECC / LAMA,PHIA,MI,ØEIGS / C,N,MØDES / V,N,NEIGV $
SAVE       NEIGV $
ØFP        LAMA,ØEIGS,,, // $
CØND       FINIS,NEIGV $
SDR1       USET,,PHIA,,,,,, / PHIG,, / C,N,1 / C,N,REIG $
SDR2       CASECC,,,EQEXIN,SIL,,,BGPDT,LAMA,,PHIG,, / ,,ØPHIG,, / C,N,REIG $
ØFP        ØPHIG,,,,, // $
JUMP       FINIS $
LABEL      E1 $
PRTPARM    // C,N,-2 / C,N,MØDES $
LABEL      FINIS $
END        $

```

Notes:

1. The echo of a test problem bulk data deck for the preceding DMAP sequence follows.

	1	2	3	4	5	6	7	8	9	10
DMI	KTEST	0	6	1	2		4	4		
DMI	KTEST	1	1	200.0	-100.0					
DMI	KTEST	2	1	-100.0	200.0	-100.0				
DMI	KTEST	3	2	-100.0	200.0	-100.0				
DMI	KTEST	4	3	-100.0	200.0					
DMI	MTEST	0	6	1	2		4	4		
DMI	MTEST	1	1	1.0						
DMI	MTEST	2	2	1.0						
DMI	MTEST	3	3	1.0						
DMI	MTEST	4	4	1.0						
EIGR	1	DET	.0	2.5	2	2			+1	
+1	MAX									
SPØINT	1	THRU	4							

2. Data block EED is generated by DPD, which copies the EIGR or EIGB cards from data block DYNAMICS. The actual card used is selected in case control by METHØD = SID.
3. Each degree-of-freedom defined by the DMI matrices must be associated with some grid or scalar point in this version. In the example above, this is done by defining four scalar points.
4. The EIGR card selected in the Case Control Deck will be used as explained in Note 2.
5. The use of module MTRXIN and DMIG bulk data cards will allow the user to input matrices via grid point identification numbers.

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5.8.8 DMAP Example to Print and Plot a Topological Picture of Two Matrices

```
1. BEGIN      $
2. SEEMAT     KGG,KLL,,, // $
3. SEEMAT     KGG,KLL,,, // C,N,PLØT / V,N,P=0 / C,N / C,N,SC / C,N,4020 / C,N,X / C,N,0 $
4. SAVE       P $
5. PRTPARM    // C,N,0 / C,N,P $
6. PARAM      // C,N,MPY / V,N,P / C,N,0 / C,N,1 $
7. SEEMAT     KGG,KLL,,, // C,N,PLØT / V,N,P / C,N / C,N,EAI / C,N,3500 / C,N,X / C,N,30 $
8. SAVE       P $
9. PRTPARM    // C,N,0 / C,N,P $
10. END       $
```

Notes:

1. Instruction number 2 causes the picture to be generated on the printer.
2. Instruction number 3 causes the picture to be generated on the SC 4020 plotter.
3. The parameter P is initialized to zero by instruction number 3. The form V,N,P would also have accomplished the same thing since the MPL default value is zero.
4. Instruction number 5 prints the current value of parameter P. Since P was initially set to zero and instruction number 3 is the first instruction executed which has P as an input, then P will have a zero value on input to instruction number 3. P is incremented by one (1) for every frame generated on the SC 4020 plotter. Since the value of the output parameter P was saved in the immediately following SAVE instruction, the value printed by instruction number 5 will be the number of frames generated by the execution of instruction number 3.
5. Instruction number 6 causes the value of P to be set to zero (0), the product of zero (0) and one (1). Since PARAM is the only module which does its own SAVE, no succeeding SAVE instruction is necessary. This illustrates a commonly used technique for setting parameter values in DMAP programs.
6. Instructions 7, 8 and 9 essentially repeat instructions 3, 4 and 5 using the EAI 3500 table plotter in place of the SC 4020 plotter.
7. The END instruction, which is required, also acts as an EXIT instruction.
8. NASTRAN tapes PLT1 and PLT2 must both be set up in order to execute this DMAP successfully.
9. Matrix data blocks KGG and KLL are assumed to exist on the PØØL file. This will be the case if either DMI input is used or if a restart is being made from a run in which KGG and KLL were generated and checkpointed.

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5.8.9 DMAP Example to Compute the r-th Power of a Matrix [Q]

```

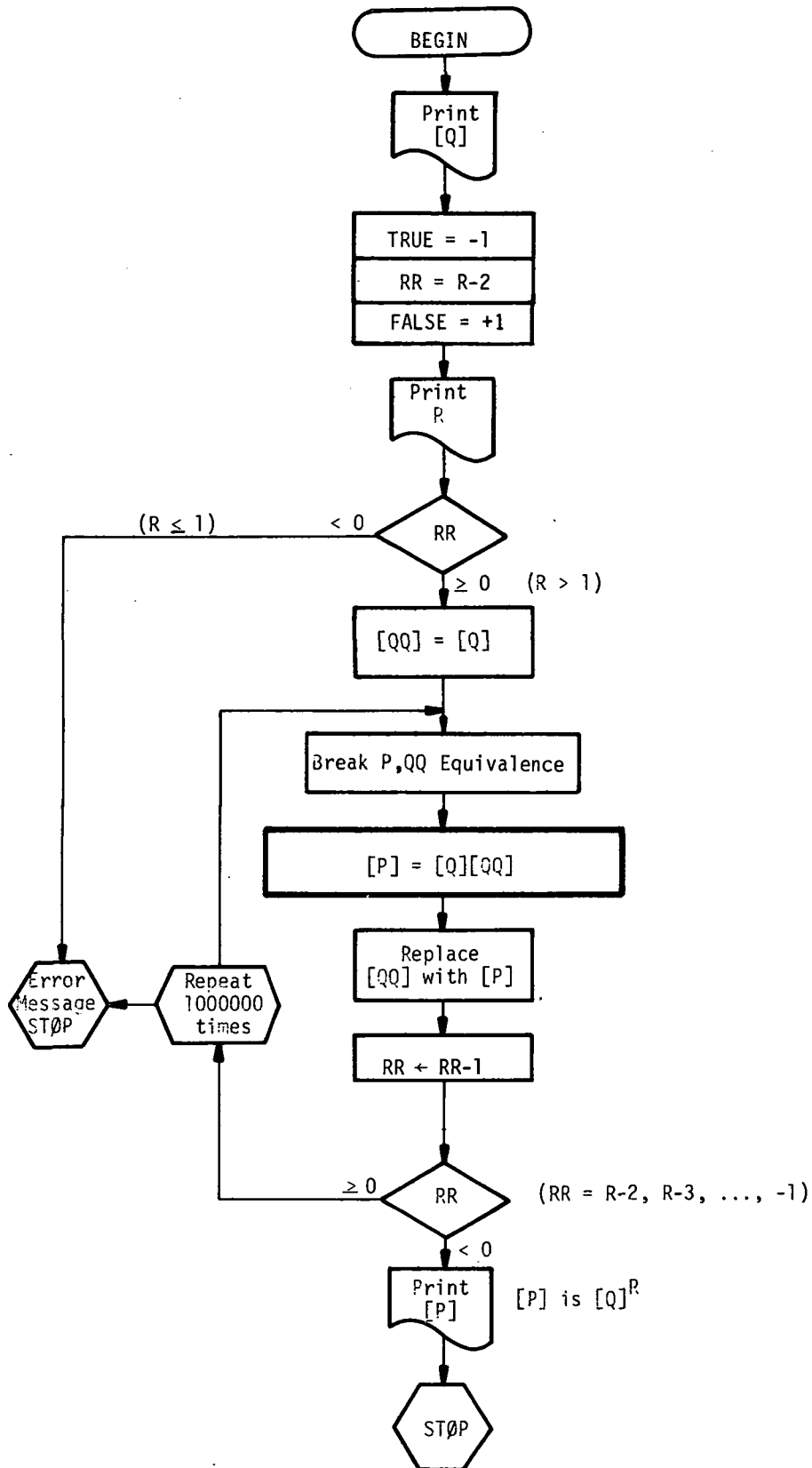
BEGIN      $
MATPRN     Q,,, // $
PARAM      // C,N,NØP / V,N,TRUE=-1 $
PARAM      // C,N,SUB / V,N,RR / V,Y,R=-1 / C,N,2 $
PARAM      // C,N,NØP / V,N,FALSE=+1 $
CØND       ERRØR1,RR $
ADD        Q, / QQ $
LABEL      DØIT $
EQUIV      QQ,P / FALSE $
MPYAD      Q,QQ, / P / C,N,0 $
EQUIV      P,QQ / TRUE $
PARAM      // C,N,SUB / V,N,RR / V,N,RR / C,N,1 $
CØND       STØP,RR $
REPT       DØIT,1000000 $
JUMP       ERRØR2 $
LABEL      STØP $
MATPRN     P,,, // $
EXIT       $
LABEL      ERRØR1 $
PRTPARM    // C,N,-1 / C,N,DMAP $
EXIT       $
LABEL      ERRØR2 $
PRTPARM    // C,N,-2 / C,N,DMAP $
EXIT       $
END        $

```

Notes:

1. The matrix [Q] is assumed input via DMI bulk data cards.
2. The parameter R is assumed input on a PARAM bulk data card.
3. A logical flow diagram for this DMAP is shown in the following sketch.

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EXAMPLES

5.8.10 Usage of UPARTN, VEC, and PARTN

In Rigid Format No. 7 (Series N), the functional modules SMP1 and SMP2 perform the following matrix operations:

$$[K_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array} \right]$$

$$[G_o] = -[K_{oo}]^{-1} [K_{oa}]$$

$$[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}]^T [G_o]$$

$$[M_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array} \right]$$

$$[A] = [M_{oo}] [G_o] + [M_{oa}]$$

$$[B] = [M_{oa}]^T [G_o] + [\bar{M}_{aa}]$$

$$[M_{aa}] = [G_o]^T [A] + [B]$$

$$[K_{ff}^u] \Rightarrow \left[\begin{array}{c|c} \bar{K}_{aa}^u & K_{ao}^u \\ \hline K_{oa}^u & K_{oo}^u \end{array} \right]$$

$$[A] = [K_{oo}^u] [G_o] + [K_{oa}^u]$$

$$[B] = [K_{oa}^u]^T [G_o] + [\bar{K}_{aa}^u]$$

$$[K_{aa}^u] = [G_o]^T [A] + [B]$$

$$[B_{ff}] \Rightarrow \left[\begin{array}{c|c} \bar{B}_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array} \right]$$

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$$[A] = [B_{oo}] [G_o] + [B_{oa}]$$

$$[B] = [B_{oa}]^T [G_o] + [\bar{B}_{aa}]$$

$$[B_{aa}] = [G_o]^T [A] + [B]$$

This is far too many time-consuming matrix operations to perform within single modules when the a-set and o-set are large. (Remember, checkpoint only occurs after the module has done all its work.) One way to break the Rigid Format Series N SMP1 into parts is to use an ALTER packet similar to the ALTER Packet which follows for Rigid Format No. 7 (Series N).

```
ALTER 97, 98 $ RIGID F0RMAT SERIES N
SMP1 USET,KFF,,,/G0,KAA,K00B,L00,U00,,,,, $
CHKPNT KAA,G0 $
SMP2 USET,G0,MFF/MAA $
CHKPNT MAA $
SMP2 USET,G0,BFF/BAA $
CHKPNT BAA $
SMP2 USET,G0,K4FF/K4AA $
CHKPNT K4AA $
ENDALTER
```

Unfortunately, most of the time is now spent in SMP2. In order to subdivide the matrix operations further, the partitions of the matrices $[K_{ff}]$ etc. must be obtained. There are two new modules introduced in Level 15 which can be used to do this. The first is UPARTN which forms the symmetric partitions of a symmetric matrix.

EXAMPLES

SMP 1 and SMP2 using UPARTN for Rigid Format No. 7 (Series N)

ALTER 96,106 \$ ALTER TØ SERIES N

\$

UPARTN USET,KFF / KØØ, ,KØA,KAAB / C,N,F / C,N,Ø / C,N,A \$

CHKPNT KØØ,KØA,KAAB \$

SØLVE KØØ,KØA / GØ / C,N,1 / C,N,-1 \$

CHKPNT GØ \$

MPYAD KØA,GØ,KAAB / KAA / C,N,1 \$

CHKPNT KAA \$

\$

UPARTN USET,MFF / MØØ, ,MØA,MAAB / C,N,F / C,N,Ø / C,N,A \$

CHKPNT MØØ,MØA,MAAB \$

MPYAD MØØ,GØ,MØA / MAATEMP1 / C,N,0 \$

CHKPNT MAATEMP1 \$

MPYAD MØA,GØ,MAAB / MAATEMP2 / C,N,1 \$

CHKPNT MAATEMP2 \$

MPYAD GØ,MAATEMP1,MAATEMP2 / MAA / C,N,1 \$

CHKPNT MAA \$

\$

UPARTN USET,K4FF / K4ØØ, ,K4ØA,K4AAB / C,N,F / C,N,Ø / C,N,A \$

CHKPNT K4ØØ,K4ØA,K4AAB \$

MPYAD K4ØØ,GØ,K4ØA / K4AATMP1 / C,N,0 \$

CHKPNT K4AATMP1 \$

MPYAD K4ØA,GØ,K4AAB / K4AATMP2 / C,N,1 \$

CHKPNT K4AATMP2 \$

MPYAD GØ,K4AATMP1,K4AATMP2 / K4AA / C,N,1 \$

CHKPNT K4AA \$

\$

UPARTN USET,BFF / BØØ, ,BØA,BAAB / C,N,F / C,N,Ø / C,N,A \$

CHKPNT BØØ,BØA,BAAB \$

MPYAD BØØ,GØ,BØA / BAATEMP1 / C,N,0 \$

CHKPNT BAATEMP1 \$

DIRECT MATRIX ABSTRACTION

```
MPYAD    B0A,G0,BAAB / BAATEMP2 / C,N,1 $  
CHKPNT   BAATEMP2 $  
MPYAD    G0,BAATEMP1,BAATEMP2 / BAA / C,N,1 $  
CHKPNT   BAA $  
$  
ENDALTER
```

In order to subdivide the matrix operations further, the partitioning information contained in USET must be made available to PARTN and MERGE so that the various matrix partitions can be formed external to SMP2 and manipulated with matrix operation modules such as MPYAD. The utility module VEC was introduced in Level 15 to accomplish this task. The ALTER Packet on the following page shows the replacement of Structural Matrix Partitioning in Rigid Format No. 7 (Series N) using this utility module.

EXAMPLES

SMP1 and SMP2 using VEC and PARTN for Rigid Format No. 7 (Series N)

```

ALTER      96,106 $
$
VEC        USET / V / C,N,F / C,N,Ø / C,N,A $
CHKPNT     V $
$
PARTN      KFF,V, / KØØ, ,KØA,KAAB $
CHKPNT     KØØ,KØA,KAAB $
DECØMP     KØØ / LØØ,UØØ / C,N,1 / C,N,0 / V,N,MIND / V,N,DET / V,N,NDET / V,N,SING $
SAVE       MIND,DET,NDET,SING $
CØND       LSING,SING $
CHKPNT     LØØ,UØØ $
FBS        LØØ,UØØ,KØA / GØ / C,N,1 / C,N,-1 $
CHKPNT     GØ $
MPYAD      KØA,GØ,KAAB / KAA / C,N,1 $
CHKPNT     KAA $
$
PARTN      MFF,V, / MØØ, ,MØA,MAAB $
CHKPNT     MØØ,MØA,MAAB $
MPYAD      MØØ,GØ,MØA / MAATEMP1 / C,N,0 $
CHKPNT     MAATEMP1 $
MPYAD      MØA,GØ,MAAB / MAATEMP2 / C,N,1 $
CHKPNT     MAATEMP2 $
MPYAD      GØ,MAATEMP1,MAATEMP2 / MAA / C,N,1 $
CHKPNT     MAA $
$
PARTN      K4FF,V, / K4ØØ, ,K4ØA,K4AAB $
CHKPNT     K4ØØ,K4ØA,K4AAB $
MPYAD      K4ØØ,GØ,K4ØA / K4AATMP1 / C,N,0 $
CHKPNT     K4AATMP1 $
MPYAD      K4ØA,GØ,K4AAB / K4AATMP2 / C,N,1 $
CHKPNT     K4AATMP2 $

```

DIRECT MATRIX ABSTRACTION

```

MPYAD      GØ,K4AATMP1,K4AATMP2 / K4AA / C,N,1 $
$
PARTN      BFF,V, / BØØ, ,BØA,BAAB $
CHKPNT     BØØ,BØA,BAAB $
MPYAD      BØØ,GØ,BØA / BAATEMP1 / C,N,0 $
CHKPNT     BAATEMP1 $
MPYAD      BØA,GØ,BAAB / BAATEMP2 / C,N,1 $
CHKPNT     BAATEMP2 $
MPYAD      GØ,BAATEMP1,BAATEMP2 / BAA / C,N,1 $
CHKPNT     BAA $
$
ALTER      180 $ ADD ERRØR TRAP FØR SINGULAR KØØ MATRIX IN R.F. 7 (SERIES N)
$
LABEL      LSING $
PRTPARM    // C,N,0 / C,N,SING $
PRTPARM    // C,N,-1 / C,N,DMAF $
EXIT       $
$
ENDALTER

```

EXAMPLES

5.8.11 DMAP Example

Let A, B and C be matrices whose values are to be defined at execution time. Let β be a real constant whose value is to be defined at execution time. Let α be an integer constant whose value (defined at execution time) determines the operations to be performed to compute matrix X as follows:

$$[X] = \begin{cases} [A][B] + [C] & , \alpha < 0 \\ [\beta[A] + [B]]^T & , \alpha = 0 \\ [A]^2[C]^{-1} & , \alpha > 0 \end{cases}$$

Write a DMAP to accomplish the above, assuming A, B and C will be defined by DMI bulk data cards and that α and β will be defined on PARAM bulk data cards. Print the inputs and outputs using the DMAP Utility Functional Modules MATPRN and PRTPARAM. Use the DMAP Utility Module SEEMAT to print a topology display of [A] and [X].

A solution to this problem is given on the following page along with data for an actual example.

DIRECT MATRIX ABSTRACTION

```

ID A,B
TIME 5
APP DMAP
BEGIN $
JUMP START $
PARAM // C,N,NØP / V,N,TRUE=-1 $ SET TRUE TØ -1 (=TRUE.)
LABEL START $
MATPRN A,B,C,, // $
CØND ØNE,ALPHA $
PARAM // C,N,NØT / V,N,CHØØSE / V,Y,ALPHA $
CØND THREE,CHØØSE $
JUMP TWØ $
$
LABEL ØNE $
MPYAD A,B,C / X / C,N,O $
JUMP FINIS $
$
LABEL TWØ $
ADD A,B / Y / C,Y,BETA=(0.0,0.0) $
TRNSP Y / X2 $
EQUIV X2,X / TRUE $
JUMP FINIS $
$
LABEL THREE $
SØLVE C, / Z $
MPYAD A,Z, / W / C,N,O $
MPYAD A,W, / X3 / C,N,O $
EQUIV X3,X / TRUE $
$
LABEL FINIS $
MATPRN X,,, // $
SEEMAT A,X,,, // C,N,PRINT $
PRTPARM // C,N,O $
END $
CEND
TITLE = TEST MPYAD
BEGIN BULK
DMI      A      0      6      1      2      2      2
DMI      A      1      1      1.01
DMI      A      2      2      1.01
DMI      B      0      6      1      2      2      2
DMI      B      1      1      1.01
DMI      B      2      2      1.01
DMI      C      0      6      1      2      2      2
DMI      C      1      1      1.01
DMI      C      2      2      1.01
PARAM    ALPHA   -1
PARAM    BETA    1.0      .0
ENDDATA

```

DIRECT MATRIX ABSTRACTION

5.9 AUTOMATIC SUBSTRUCTURE DMAP ALTERS

In the automated substructure process, the user commands (described in Section 2.7) are converted to the form of DMAP instructions via ALTER card equivalents. This section describes the resulting DMAP data for each command.

The "raw DMAP" data, stored in the program and modified according to the user input data, is listed by command type. The fields in the raw DMAP to be modified, or "variables", are underlined (i.e., XXX). The subcommand control cards are identified by parentheses on the right side. For example, the (P only) for the SUBSTRUCTURE command item 12, implies that this DMAP instruction is included only if the OPTION request includes P (loads).

The ALTER card images are not true DMAP instructions but are used to locate positions in the existing DMAP Rigid Format for replacement by or insertion of the new DMAP instructions. The locations to be specified depend on the Rigid Format selected by the SOL Executive Control Card and are listed in Section 3 for each Rigid Format. The relevant section of the Rigid Format for each ALTER is indicated by the note in parentheses. For instance "After GP4" in Rigid Format 1 (statics) implies "ALTER 54" for insertion of the corresponding DMAP instructions following Rigid Format Series N instruction number 54. If an existing set of DMAP instructions is to be removed, the parenthetical note may indicate "Remove DECØMP", where DECØMP may be a set of NASTRAN modules related to the entire decomposition process.

The descriptions given below are highly dependent on the user input commands and the Rigid Format selected. For an exact listing of all DMAP data generated for the current set of substructure commands, the DIAG 23 Executive Control Card may be input. Adding DIAG 24 will produce a punched deck of the actual ALTER cards generated. This feature allows the user to modify these alters and execute under APP DMAP.

DIRECT MATRIX ABSTRACTION

5.9.1 Index of Substructure DMAP ALTERs

<u>ALTER</u>	<u>Basic Function</u>	<u>Page</u>
BRECØVER	Convert Phase 2 results to solution vectors	5.9-3
CØMBINE	Combine several substructures	5.9-4
DELETE	Internal utility commands	5.9-5
DESTRØY		
EDIT		
EQUIV		
RENAME		
SØFPRINT		
PLØT	Plot substructures	5.9-6
RECØVER	Recover and output Phase 2 solution data	5.9-7
REDUCE	Initiate matrix partitioning operations	5.9-8
RUN	Define the DRY parameter	5.9-9
SØFIN	File operators	5.9-10
SØFØUT		
RESTØRE		
DUMP		
CHECK		
SØLVE	Provide data for execution of the solution phase	5.9-11
SUBSTRUCTURE	Initiate the automatic DMAP process	5.9-12

AUTOMATIC SUBSTRUCTURE DMAP ALTERS

5.9.2 DMAP for Command: BRECOVER (Phase 3)

The BRECOVER command converts the results of a Phase 2 substructure analysis to NASTRAN solution vectors for the detailed calculation of basic structure (or an equivalent basic substructure) displacements, forces, loads, and stresses. The same structure model of the primary substructure defined in Phase 1 must be used in Phase 3. It is possible to perform the Phase 3 execution either as a restart of the Phase 1 run or as an independent run, which recalculates the necessary data blocks.

Raw DMAP:

```

1  ALTER      (Remove solution)
2  PARAM      //C,N,NØP/V,N,ALWAYS=-1 $
3  SSG2       USET,GM,YS,KFS,GØ,,PG/QR,PØ,PS,PL $ (P only)
4  RCØVR3     ,PG,PS,PØ,YS/ULV,QSS,PGS,PSS,POS,YSS,LAMA/C,N,SØLN/
5             C,N,NAME $
6  EQUIV      PGS,PG/ALWAYS/PØS,PØ/ALWAYS/YSS,YS/ALWAYS/PSS,PS/ALWAYS $ (P only)
7  $
8  CØND       LBSXXX,ØMIT $
9  FBS        LØØ,VØØ,PØS/UØØV/C,N,1/C,N,1/C,N,PREC/C,N,1 $ } (P only)
10 LABEL     LBSXXX $
11 ØFP        LAMA,,,,,//V,N,CARDNØ$
12 ALTER      (After SDR1)
13 UMERGE     USET,QSS,/QGS/C,N,G/C,N,A/C,N,O $
14 ADD        QG,QGD/QGT $
15 EQUIV      QGT,QG/ALWAYS $

```

Variables:

SØLN = Rigid Format solution number
 PG,PS,PØ,YS = Remove data blocks if ØPTION not P
 NAME = Name of basic Phase 1 substructure, corresponding to input data
 XXX = Step number

DIRECT MATRIX ABSTRACTION

5.9.3 DMAP for Command: CØMBINE

The CØMBINE command initiates the process for combining several substructures defined on the SØF files. The CØMB1 module reads the control deck and the Bulk Data cards and builds the tables and transformation matrices for the combination structure. • The CØMB2 module performs the matrix transformations using the matrices stored on the SØF file or currently defined as NASTRAN data blocks. The resultant matrices are stored on the SØF file and retained as NASTRAN data blocks.

Raw DMAP:

1	CØMB1	CASECC,GEØM4//C,N,STP/S,N,DRY/C,N,PØPT \$	
2	CØND	LBSTP,DRY \$	
3	CØMB2	,KNØ1,KNØ2,KNØ3,KNØ4,KNØ5,KNØ6,KNØ7/KNSC/S,N,DRY/C,N,K/	} (K only)
4		C,N,NAMEØØØ1/C,N,NAMEØØØ2/C,N,NAMEØØØ3/C,N,NAMEØØØ4/C,N,	
5		DUMPARAM/C,N,NAMEØØØ5/C,N,NAMEØØØ6/C,N,NAMEØØØ7 \$	
6	SØFØ	,KNSC,,//S,N,DRY/C,N,NAMEC/C,N,KMTX \$	
7	CØMB2	MNØ1,MNØ2,MNØ3,MNØ4,MNØ5,MNØ6,MNØ7/MNSC/V,N,DRY/C,N,M/	} (M only)
8		C,N,NAMEØØØ1/C,N,NAMEØØØ2/C,N,NAMEØØØ3/C,N,NAMEØØØ4/C,N,	
9		DUMPARAM/C,N,NAMEØØØ5/C,N,NAMEØØØ6/C,N,NAMEØØØ7 \$	
10	SØFØ	,MNSC,,//S,N,DRY/C,N,NAMEC/C,N,MMTX \$	
11	CØMB2	,PNØ1,PNØ2,PNØ3,PNØ4,PNØ5,PNØ6,PNØ7/PNSC/V,N,DRY/C,N,P/	} (P or PA only)
12		C,N,NAMEØØØ1/C,N,NAMEØØØ2/C,N,NAMEØØØ3/C,N,NAMEØØØ4/C,N,	
13		PØPT/C,N,NAMEØØØ5/C,N,NAMEØØØ6/C,N,NAMEØØØ7 \$	
14	SØFØ	,PNSC,,//S,N,DRY/C,N,NAMEC/C,N,PVEC \$	
15	LABEL	LBSTP \$	
16	LØDAPP	PNSC//S,N,DRY/C,N,NAMEC \$	} (PA only)

Variables:

NAMEØØØ1,NAMEØØØ2,...;etc.	= Names of pseudostructures to be combined
NØ1,NØ2,...;etc.	= Internal number for structures to be combined
NAMEC	= Name of combined structure
NSC	= Internal number of combined structure
STP	= Step number
PØPT	= Flag for appended loads (ØPTIØN=PA)

AUTOMATIC SUBSTRUCTURE DMAP ALTERS

5.9.4 DMAP for Utility Commands: DELETE, DESTROY, EDIT, EQUIV, RENAME, SØFPRINT

Several internal operations of the SØF may be performed with the utility commands which create various calls to the SØFUT module. Each of the commands and associated data are inserted as parameters.

Raw DMAP:

```
1 SØFUT //V,N,DRY/C,N,NAME/C,N,ØPER/C,N,ØPT/C,N,NAME0002/C,N,PREF/
2 C,N,DUMPARAM/C,N,ITM1/C,N,ITM2/C,N,ITM3/C,N,ITM4/C,N,ITM5 $
```

Variables:

NAME = Name of substructure
 ØPER = Operation to be performed (first four characters of command, i.e., EDIT)
 ØPT = Integer option code
 NAME0002 = Second substructure name for EQUIV and RENAME
 PREF = Prefix for EQUIV operation
 ITM1,ITM2, etc. = SØF data item names

The following chart describes the variables used for each command.

Command	NAME	ØPER	ØPT	NAME0002	PREF	ITM1, etc.
DELETE	X	X				X
DESTROY	X	X				
EDIT	X	X	X			
EQUIV	X	X		X	X	
RENAME	X	X		X		
SØFPRINT	X	X	X			X

DIRECT MATRIX ABSTRACTION

5.9.5 DMAP for Substructure Plots: PLØT

Any level of substructure may be plotted as an undeformed shape using the existing NASTRAN plot logic. The plot sets generated in Phase 1 are combined and transformed for that plotting.

Raw DMAP:-

```
1  PLTMRG    CASECC,PCDB/PLTXXX,GPXXX,ELXXX,BCXXX,CASXXX,EQXXX/C,N,  
2            NAME/V,N,NGP/V,N,LSIL/V,N,NPSET $  
3  SAVE      NGP,LSIL,NPSET $  
4  SETVAL    //V,N,PLTFLG/C,N,1/V,N,PFIL/C,N,0 $  
5  SAVE      PLTFLG,PFIL $  
6  PLØT      PLTXXX,GPXXX,BLXXX,CASXXX,BGXXX,FQXXX,,,/PMXXX/V,N,NGP/V,N,  
7            LSIL/V,N,NPSET/V,N,PLTFLG/V,N,PFIL $  
8  SAVE      NPSET,PLTFLG,PFIL $  
9  PRTMSG    PMXXX// $
```

Variables:

NAME - Name of substructure to be plotted
XXX - Step number

AUTOMATIC SUBSTRUCTURE DMAP ALTERS

5.9.6 DMAP for Command: RECOVER (Phase 2)

This operation performs the recovery and output of the Phase 2 solution data. The NASTRAN solution displacement vector is transformed and expanded to correspond to the degrees of freedom of the selected component substructures. Each pass through the DMAP loop corresponds to a requested structure to be processed. The RCØVR module selects the substructure to be processed with the loop counter, ILØØP.

Raw DMAP:

```

1  $RECOVER  PHASE 2 (Follows preceding command sequence)
2  PARAM      //C,N,NØP/V,N,ILØØP=0 $
3  LABEL      LBSTP $
4  RCØVR      CASESS,GELA,KGG,MGG,PG,UGPH/ØUG1,ØPG1,ØQG1,U1,U2,U3,
5             U4,U5/V,N,DRY/V,N,ILØØP/C,N,STP/C,N,NAMEFSS/C,N,NSØL/
6             V,N,NEIGV/V,N,LUI/V,N,U1N/V,N,U2N/V,N,U3N/V,N,U4N/V,N,U5N $
7  SAVE      DRY,ILØØP,LUI,U1N,U2N,U3N,U4N,U5N $
8  ØFP       ØUG1,ØQG1,ØPG1,,,//V,N,CARDNØ $
9  SAVE      CARDNØ
10 CØND      LBBSTP,ILØØP $
11 REPT      LBSTP,100 $
12 LABEL     LBBSTP $

```

Variables:

GELA	= GEMØ4 or LAMA depending on rigid format
KGG,MGG,PG	= Data blocks which depend on ØPTION
UGPH	= UGV or PHIG depending on rigid format
STP	= Step number
NAMEFSS	= Name of solution structure
NSØL	= Rigid Format solution number

DIRECT MATRIX ABSTRACTION

5.9.7 DMAP for Command: REDUCE

The REDUCE command initiates the matrix partitioning operations to be performed on the stiffness, mass, and load vectors in order to produce a set of matrices defined by a subset of the original degrees of freedom. The REDUCE module generates the partitioning vector PV, a USET data block US, and an identity matrix IN from the Bulk Data and the corresponding substructure tables stored on the SØF. The remainder of the DMAP sequence directs the actual matrix operations.

Raw DMAP:

1	REDUCE	CASECC,GEØM4/PVNOA,USXXX,INXXX/C,N,STP/V,N,DRY/C,N,PØPT \$	
2	SAVE	DRY \$	
3	CØND	LBRSTP,DRY \$	
4	SØFI	/KNOA,MNOA.PNOA,,/V,N,DRY/C,N,NAMEØØØA/C,N,KMTX/	
5		C,N,MMTX/C,N,PVEC \$	
6	SAVE	DRY \$	
7	CØND	LBRSTP,DRY \$	
8	SMP1	USXXX,KNOA,,/GØNOA,KNOB,KØNOA,LØNOA ,,,, \$	}
9	MERGE	GØNOA,INXXX,,,PVNOA/GNOA/C,N,1/C,N,TYP/C,N,2 \$	
10	SØFØ	GNOA,LØNOA,,/V,N,DRY/C,N,NAMEØØØA/C,N,HØRG/C,N,LMTX \$	
11	SØFØ	KNOB,,/V,N,DRY/C,N,NAMEØØØB/C,N,KMTX \$	
12	SØF1	/GNOA,,/V,N,DRY/C,N,NAMEØØØA/C,N,HØRG \$ (if not K)	
13	MPYAD	MNOA,GNOA,/MXXX/C,N,0/C,N,1/C,N,0/C,N,TYP \$	}
14	MPYAD	GNOA,MXXX,/MNOB/C,N,1/C,N,1/C,N,0/C,N,TYP \$	
15	PARTN	PNOA,,PVNOA/PØNOA,,/C,N,1/C,N,1/C,N,2 \$	}
16	MPYAD	GNOA,PNOA,/PNOB/C,N,1/C,N,1/C,N,0/C,N,1 \$	
17	SØFØ	PØNOA,PVNOA,,/V,N,DRY/C,N,NAMEØØØA/C,N,PØVE/C,N,UPRT \$	
18	SØFØ	MNOB,PNOB,,/V,N,DRY/C,N,NAMEØØØB/C,N,MMTX/C,N,PØPT \$	
19	LØDAPP	PNOB,PØNOA//V,N,DRY/C,N,NAMEØØØB \$	
20	LABEL	LBRSTP \$	

Variables:

XXX,SPT = Step number
 NAMEØØØA = Name of input structure, A.
 NAMEØØØB = Name of output structure, B.
 NOA,NOB = Internal numbers of substructures A and B.
 TYP = Matrix precision flag (1 = single)
 PØPT,PØVE = Flags for appended loads (ØPTION=PA)

AUTOMATIC SUBSTRUCTURE DMAP ALTERS

5.9.8 DMAP for Command: RUN

The RUN command defines the DRY parameter for use by the subsequent DMAP instructions. If the user specifies RUN=DRYGØ, a special set of DMAP instructions are placed at the end of the entire command sequence.

Raw DMAP:

```
PARAM      //C,N,ADD/V,N,DRY/C,N,I/C,N,0 $
```

Variables:

I = Integer code for RUN option (DRY = -1, GØ = 0, STEP = 1)

If RUN=DRYGØ, I is set to (DRY) initially and the following DMAP is inserted at the end of the complete ALTER stream:

```
LABEL      LBSEND
PARAM      //C,N,ADD/V,N,DRY/V,N,DRY/C,N,1 $
COND       FINIS,DRY $
REPT       LBSBEG,1 $
JUMP       FINIS $
```

DIRECT MATRIX ABSTRACTION

5.9.9 DMAP for External I/O Commands: SØFIN, SØFØUT, RESTØRE, DUMP, CHECK

Several operations may be performed on the NASTRAN user files and the SØF file using the EXIØ module. The various input parameters are set by the Substructure Commands.

Raw DMAP:

```
1  EXIØ      //V,N,DRY/C,N,O/C,N,DEVI/C,N,UNITNAME/C,N,FØRM/C,N,MØDE/
2            C,N,PØSI/C,N,ITEM/C,N,NAME0001/C,N,NAME0002/E,N,NAME0003/
3            C,N,NAME0004/C,N,NAME0005 $
```

Variables:

MØDE = First four characters of command name (i.e., 'SØFI', 'REST')
 DEVI = Device used for I/O file ('TAPE' or 'DISK')
 UNITNAME = Name of NASTRAN user file assigned to I/O file (i.e., INPT, INP1, etc.)
 FØRM = Format of data ('EXTE' or 'INTE')
 PØSI = Position of file on device ('REWI', 'NØRE', or 'EØF')
 ITEM = Name of SØF item or 'ALL', 'MATR', 'TABL', or 'PHAS'
 NAME0001, etc. = Names of substructures to be copied.

The following chart describes the variables used for each command:

Command	MØDE	DEVI	UNITNAME	FØRM	PØSI	ITEM	NAME000 _i
SØFIN	X	X	X	X	X	X	X
SØFØUT	X	X	X	X	X	X	X
RESTØRE	X	X	X				
DUMP	X	X	X				
CHECK	X	X	X				

AUTOMATIC SUBSTRUCTURE DMAP ALTERS

5.9.10 DMAP for Command: SØLVE

The SØLVE command provides the necessary data for execution of the solution phase of NASTRAN. Module SGEN replaces the NASTRAN GP1 module for the purpose of defining an equivalent pseudostructure from data blocks. The new data blocks GE3S and GE4S contain the load and constraint data in the form of converted Bulk Data card images. The stiffness and mass matrices are obtained from the SØF files and added to any user matrix terms.

Raw DMAP:

```

1  ALTER      (Remove GP1)
2  PARAM      //C,N,NØP/V,N,ALWAYS=-1 $
3  SGEN       CASECC,GEØM3,GEØM4/CASESS,CASEI,GPL,EQEXIN,GPD,T,BGPD,T,SIL,
4             GE3S,GE4S,CSTM/V,N,DRY/C,N,NAMESØLS/V,N,LUSET/V,N,NØGPD,T $
5  SAVE       DRY,LUSET,NØGPD,T $
6  EQUIV      GE3S,GEØM3/ALWAYS/GE4S,GEØM4/ALWAYS/CASEI,CASECC/ALWAYS $
7  CØND       LBSTP/DRY $
8  ALTER      (Remove PLØT)
9  ALTER      (Remove NØSIMP CØND)
10 CØND       LBSØL,NØSIMP $
11 ALTER      (Remove SMA3)
12 LABEL      LBSØL $
13 SØFI       /KNØS,MNØS,.,./V,N,DRY/C,N,NAMESØLS/C,N,KNTX/C,N,MMTX $
14 EQUIV      KNØS,KGG/NØSIMP $ (K only)
15 EQUIV      MNØS,MGG/NØSIMP $ (M, only used for Rigid Formats 2 and 3)
16 CØND       LBSTP,NØSIMP $
17 ADD        KGGX,KNØS/KGG/ $ (K only)
18 ADD        MGG,MNØS/MGGX/ $
19 EQUIV      MGGX,MGG/ALWAYS $ (M, only used for Rigid Formats 2 and 3)
20 LABEL      LBSTP
21 CHKPNT     MGG $ (M, only used for Rigid Formats 2 and 3)
22 ALTER      (After GP4)
23 CØND       LBSEND,DRY $
24 ALTER      (Remove SDR2-PLØT)

```

Variables

NAMESØLS = Name of solution structure
 NØS = Internal number of solution structure
 STP = Step number

DIRECT MATRIX ABSTRACTION

5.9.11 DMAP for Command: SUBSTRUCTURE

The SUBSTRUCTURE command is necessary to initiate the automatic DMAP process. In Phase 1, the SUBPH1 module is used to build the substructure tables on the SØF from the NASTRAN grid point tables and the SØFØ module is used to copy the matrices onto the SØF. In Phase 2 and Phase 3, the initial value of the DRY parameter is set and the DMAP sequence is initiated.

Raw DMAP:

PHASE 1

```

1  ALTER      (After GP4)
2  PARAM      //C,N,ADD/V,N,DRY/C,N,I/C,N,O $
3  LABEL      LBSBEG $
4  CØND       LBLIS,DRY $
5  ALTER      (Remove DECØMP)
6  LABEL      LBLIS $
7  ALTER      (Remove solution)
8  SUBPH1     CASECC,EQEXIN,USET,BGPDT,CSTM,GPSETS,ELSETS//V,N;
9             DRY/C,N,NAME/C,N,PLØTID/C,N,PØPT $
10 SAVE       DRY $
11 CØND       LBSEND,DRY $
12 SSG2       USET,GM,YS,KFS,GØ,,PG/QR,PØ,PS,PL $ (P or PA only)
13 CHKPNT     PØ,PS,PL $
14 SØFØ       ,KAA,MAA,PL,,//V,N,DRY/C,N,NAME/C,N,KMTX/C,N,MMTX/C,N,PVEC $
15 LØDAPP     PL,//V,N,DRY/C,N,NAME $ (PA only)

```

PHASE2

```

1  ALTER      2,0
2  PARAM      //C,N,ADD/V,N,DRY/C,N,I/C,N,O $
3  LABEL      LBSBEG $

```

PHASE 3

```

1  ALTER      (Remove DECØMP)
2  PARAM      //C,N,ADD/V,N,DRY/C,N,I/C,N,O $
3  LABEL      LBSBEG $

```

Variables:

I = Integer RUN option code (see RUN command)
 NAME = Phase 1 substructure name
 PLØTID = Phase 1 Plot Set ID
 KAA,MAA,PL = Data blocks dependent on ØPTION
 PØPT = Flag for appended loads (ØPTION=PA)

DIAGNOSTIC MESSAGES

6.1 RIGID FORMAT DIAGNOSTIC MESSAGES

A number of fatal errors are detected by DMAP statements in the various rigid formats. These messages indicate the presence of fatal user errors that, either cannot be determined by the functional modules, or that can be more effectively detected by DMAP statements in the rigid format. The detection of such an error causes a transfer to a LABEL instruction near the end of the rigid format. The text of the message is output and the execution is terminated. These messages will always appear at the end of the NASTRAN output.

6.1.1 Displacement Approach Rigid Formats

The texts of the rigid format error messages are given in the following sections for each of the displacement approach rigid formats. The text for each message is given in capital letters and is followed by additional explanatory material, including suggestions for remedial action.

6.1.1.1 Rigid Format Error Messages for Static Analysis

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIONS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subsets 1 or 3. The problem should be restarted on subset 0.

6.1.1.2 Rigid Format Error Messages for Static Analysis with Inertia Relief

NØ. 1 - MASS MATRIX REQUIRED FØR CALCULATION ØF INERTIA LØADS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

DIAGNOSTIC MESSAGES

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - FREE BØDY SUPPØRTS ARE REQUIRED.

A statically determinate set of supports must be specified on a SUPØRT card in order to determine the rigid body characteristics of the structural model.

NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subsets 1 or 3. The problem should be restarted on subset 0.

6.1.1.3 Rigid Format Error Messages for Normal Mode Analysis

NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.1.4 Rigid Format Error Messages for Static Analysis with Differential Stiffness

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BØDY SUPPØRTS NØT ALLOWED.

Free bodies are not allowed in Static Analysis with Differential Stiffness. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 scale factors for differential stiffness calculations. This number may be increased by altering the REPT instruction following SDRI.

NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIONS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 5 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

RIGID FORMAT DIAGNOSTIC MESSAGES

NO. 6 - A LOOPING PROBLEM RUN ON NON-LOOPING SUBSET.

A problem requiring multiple differential load factor was run on subset (1 or 3) which does not support them. The problem should be restarted on subset 0.

6.1.1.5 Rigid Format Error Messages for Buckling Analysis

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BODY SUPPORTS NOT ALLOWED.

Free bodies are not allowed in Buckling Analysis. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGB card and METHØD must select an EIGB set in the Case Control Deck.

NØ. 4 - NØ EIGENVALUES FOUND.

No buckling modes exist in the range specified by the user.

NØ. 5 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 6 - NØ INDEPENDENT DEGREES OF FREEDOM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPØ, MPC, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.1.6 Rigid Format Error Messages for Piecewise Linear Analysis

NØ. 1 - NØ NONLINEAR ELEMENTS HAVE BEEN DEFINED.

A piecewise linear problem has not been formulated because none of the elements have a stress dependent modulus of elasticity defined on a Material card.

NØ. 2 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

An attempt has been made to use more than 100 load increments. This number may be increased by altering the REPT instruction preceding SDR2.

NØ. 3 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - STIFFNESS MATRIX SINGULAR DUE TO MATERIAL PLASTICITY.

The stiffness matrix is singular due either to one or more grid point singularities or element material plasticity.

DIAGNOSTIC MESSAGES

6.1.1.7 Rigid Format Error Messages for Direct Complex Eigenvalue Analysis.

NØ. 1 - EIGENVALUE EXTRACTION DATA REQUIRED FOR COMPLEX EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGC card and CMETHOD must select an EIGC set in the Case Control Deck.

NØ. 2 - ATTEMPT TO EXECUTE MORE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number may be increased by altering the REPT instruction following SDR2.

NØ. 3 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS

The mass matrix is null because either no elements were defined on Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

6.1.1.8 Rigid Format Error Messages for Direct Frequency and Random Response.

NØ. 1 - FREQUENCY RESPONSE LIST REQUIRED FOR FREQUENCY RESPONSE CALCULATIONS.

Frequencies to be used in the solution of frequency response problems must be supplied on a FREQ, FREQ1, or FREQ2 card and FREQ must select a frequency response set in the Case Control Deck.

NØ. 2 - DYNAMIC LØADS TABLE REQUIRED FOR FREQUENCY RESPONSE CALCULATIONS.

Dynamic loads to be used in the solution of frequency response problems must be specified on an RLØAD1 or RLØAD2 card and DLØAD must select a dynamic load set in the Case Control Deck.

NØ. 3 - ATTEMPT TO EXECUTE MORE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number may be increased by altering the REPT instruction following the last ØFP instruction.

NØ. 4 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.

The mass matrix is null because either no elements were defined on Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

6.1.1.9 Rigid Format Error Message for Direct Transient Response

NØ. 1 - TRANSIENT RESPONSE LIST REQUIRED FOR TRANSIENT RESPONSE CALCULATIONS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

NØ. 2 - ATTEMPT TO EXECUTE MORE THAN 100 LØØPS.

An attempt has been made to use more than 100 dynamic load sets. This number may be increased by altering the REPT instruction following the last XYPLØT instruction.

NØ. 3 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

RIGID FORMAT DIAGNOSTIC MESSAGES

6.1.1.10 Rigid Format Error Messages for Modal Complex Eigenvalue Analysis.

NØ. 1 - MASS MATRIX REQUIRED FOR MODAL FORMULATION.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHOD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

An attempt has been made to use more than 100 different sets of direct input matrices. This number can be increased by altering the REPT instruction following SDR2.

NØ. 4 - REAL EIGENVALUES REQUIRED FOR MODAL FORMULATION.

No real eigenvalues were found in the frequency range specified by the user.

6.1.1.11 Rigid Format Error Messages for Modal Frequency and Random Response.

NØ. 1 - MASS MATRIX REQUIRED FOR MODAL FORMULATION.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHOD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number can be increased by altering the REPT instruction following the last OFP instruction.

NØ. 4 - REAL EIGENVALUES REQUIRED FOR MODAL FORMULATION.

No real eigenvalues were found in the frequency range specified by the user.

NØ. 5 - FREQUENCY RESPONSE LIST REQUIRED FOR FREQUENCY RESPONSE CALCULATIONS.

Frequencies to be used in the solution of frequency response problems must be supplied on a FREQ, FREQ1, or FREQ2 card and FREQ must select a frequency response set in the Case Control Deck.

NØ. 6 - DYNAMIC LOADS TABLE REQUIRED FOR FREQUENCY RESPONSE CALCULATIONS.

Dynamic loads to be used in the solution of frequency response problems must be specified on an RLØAD1 or RLØAD2 card and DLØAD must select a dynamic load set in the Case Control Deck.

6.1.1.12 Rigid Format Error Messages for Modal Transient Response.

NØ. 1 - MASS MATRIX REQUIRED FOR MODAL FORMULATION.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

DIAGNOSTIC MESSAGES

NØ. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHOD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

An attempt has been made to use more than 100 dynamic load sets. This number can be increased by altering the REPT instruction following the last XYPLØT instruction.

NØ. 4 - REAL EIGENVALUES REQUIRED FOR MODAL FORMULATION.

No real eigenvalues were found in the frequency range specified by the user.

NØ. 5 - TRANSIENT RESPONSE LIST REQUIRED FOR TRANSIENT RESPONSE CALCULATIONS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

6.1.1.13 Rigid Format Error Messages for Normal Modes with Differential Stiffness.

NØ. 1 - NO STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BODY SUPPORTS NOT ALLOWED.

Free bodies are not allowed in Normal Modes with Differential Stiffness. The SUPPORT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - EIGENVALUE EXTRACTION DATA REQUIRED FOR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHOD must select an EIGR set in the Case Control Deck.

NØ. 4 - NO EIGENVALUE FOUND.

No eigenvalues were found in the frequency range specified by the user.

NØ. 5 - MASS MATRIX REQUIRED FOR REAL EIGENVALUE ANALYSIS.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 6 - NO INDEPENDENT DEGREES OF FREEDOM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPPORT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.1.14 Rigid Format Error Messages for Statics using Cyclic Symmetry.

NØ. 1 - ATTEMPT TO EXECUTE MORE THAN 100 LOOPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDRI.

NØ. 2 - MASS MATRIX REQUIRED FOR WEIGHT AND BALANCE CALCULATIONS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

RIGID FORMAT DIAGNOSTIC MESSAGES

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Statics with Cyclic Symmetry. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 6 - CYCLIC SYMMETRY DATA ERRØR.

See Section 1.12 for proper modeling techniques and corresponding PARAM card requirements.

6.1.1.15 Rigid Format Error Messages for Normal Modes using Cyclic Symmetry.

NØ. 1 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Normal Modes with Cyclic Symmetry. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 5 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 6 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no structural elements have been defined with Connection cards.

DIAGNOSTIC MESSAGES

6.1.2 Heat Approach Rigid Formats

The texts of the rigid format error messages are given in the following sections for each of the heat approach rigid formats. The text for each message is given in capital letters and is followed by additional explanatory material, including suggestions for remedial action.

6.1.2.1 Rigid Format Error Messages for Static Heat Transfer Analysis

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - A LØØPING PROBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subset 1. The problem should be restarted on subset 0.

6.1.2.2 Rigid Format Error Messages for Nonlinear Static Heat Transfer Analysis

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of direct input matrices. This number can be increased by altering the REPT instruction following SDR2.

NØ. 2 - NØ SIMPLE STRUCTURAL ELEMENTS.

The heat conduction matrix is null because no Connection cards (other than GENEL) have been defined.

NØ. 3 - STIFFNESS MATRIX SINGULAR.

The heat conduction matrix is singular due to unspecified grid point temperatures.

6.1.2.3 Rigid Format Error Message for Transient Heat Transfer Analysis

NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIONS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

RIGID FORMAT DIAGNOSTIC MESSAGES

6.1.3 Aero Approach Rigid Format

The texts of the rigid format error messages are given in the following section for the aero approach rigid format. The text for each message is given in capital letters and is followed by additional explanatory material, including suggestions for remedial action.

6.1.3.1 Rigid Format Error Messages for Modal Flutter Analysis

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATION.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of direct input matrices. This number can be increased by altering the REPT instruction following FA2.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATION.

No real eigenvalues were found in the frequency range specified by the user.

DIAGNOSTIC MESSAGES

6.2 NASTRAN SYSTEM AND USER MESSAGES

NASTRAN system and user messages are identified by number. Message numbers have been assigned in groups as follows:

1 - 1000	Preface Messages
1001 - 2000	Executive Module Messages
2001 -	Functional Module Messages

These messages have the following format:

$$*** \quad \left\{ \begin{array}{c} \text{SYSTEM} \\ \text{USER} \end{array} \right\} \quad \left\{ \begin{array}{c} \text{FATAL} \\ \text{WARNING} \\ \text{INFORMATION} \end{array} \right\} \quad \text{MESSAGE id, text.}$$

where "id" is a unique message identification number and "text" is the message as indicated in capital letters for each of the diagnostic messages. A series of asterisks (****) in the text indicates information that will be filled in for a specific use of the message, such as, the number of a grid point or the name of a bulk data card. Many of the messages are followed by additional explanatory material, including suggestions for remedial action.

The system and user messages described in this section pertain only to those messages generated by NASTRAN. Although these messages can appear at various places in the output stream, they should be easily identified by their format. The various computer operating systems also produce diagnostic messages that can appear at various places in the output stream. The format of these messages will vary with the operating system. Reference should be made to the operating system manuals for interpretation of the messages that are not generated by NASTRAN.

System messages refer to diagnostics that are associated with program errors. In general such errors cannot be corrected by the user. Reference should be made to the Programmer's Manual and assistance secured from the programming staff. User messages refer to errors that are usually associated with the preparation of the NASTRAN Data Deck. Corrective action is indicated in the message text or the explanatory information following the text. In some cases reference may have to be made to other sections of the User's Manual for proper card formats or for clarification of procedures.

Fatal messages cause the termination of the execution following the printing of the message, text. These messages will always appear at the end of the NASTRAN output. Warning and information

DIAGNOSTIC MESSAGES

messages will appear at various places in the output stream. Such messages only convey warnings or information to the user. Consequently, the execution continues in a normal manner following the printing of the message text.

As an example, consider message number 2025, which will appear in the printed output as follows:

*** USER FATAL MESSAGE 2025, UNDEFINED COORDINATE SYSTEM 102.

The three leading asterisks (***) are always present in user and system diagnostic messages. The word USER indicates that this is a user message rather than a system message. The word FATAL indicates that this is a fatal message rather than a warning or information message. The number 2025 is the identification number for this message. The text of the message follows the comma (,). The number 102 replaces the asterisks (****) in the general message text, and indicates that 102 is the identification number of the undefined coordinate system.

6.2.1 Preface Messages

01 *** USER WARNING MESSAGE 1, ASSUMED FIRST INPUT FILE IS NULL.

User has specified N input data blocks when there should be N+1.

02 *** USER WARNING MESSAGE 2, PARAMETER NAMED ***** IS DUPLICATED.

No harm done. Parameter is saved just once.

03 *** USER FATAL MESSAGE 3, FORMAT ERROR IN PARAMETER NØ.***.

Double delimiter appears in parameter section of previous DMAP instruction.

04 *** SYSTEM FATAL MESSAGE 4, MPL PARAMETER ERROR, MODULE NAME = ***** PARAMETER NØ.***.

MPL entry for module is incorrect. See block data program XMPLBD.

05 *** USER FATAL MESSAGE 5, PARAMETER INPUT DATA ERROR ILLEGAL VALUE FOR PARAMETER NAMED *****.

Type of parameter on PARAM card is inconsistent with type of parameter by same name in above DMAP instruction.

06 *** USER FATAL MESSAGE 6, ILLEGAL VALUE FOR PARAMETER NØ.***.

The type of parameter in DMAP instruction does not correspond to type requested in DMD or MFD section of Programmer's Manual.

07 *** USER FATAL MESSAGE 7, PARAMETER NØ.*** NEEDS PARAMETER NAME.

Parameter is not in correct format.

NASTRAN SYSTEM AND USER MESSAGES

08 *** USER FATAL MESSAGE 8, BULK DATA PARAM CARD ERROR. MUST NOT DEFINE PARAMETER NAMED *****.

The "N" in V,N,***** means user cannot set the value of the parameter with name ***** on a PARAM card.

09 *** USER FATAL MESSAGE 9, VALUE NEEDED FOR PARAMETER NO. ***.
Constant needs value in DMAP instruction or on PARAM card.

10 *** USER FATAL MESSAGE 10, ILLEGAL INPUT SECTION FORMAT.

11 *** USER FATAL MESSAGE 11, ILLEGAL OUTPUT SECTION FORMAT.

12 *** USER FATAL MESSAGE 12, ILLEGAL CHARACTER IN DMAP INSTRUCTION NAME.
Name must be 8 or less alpha-numeric characters, the first character being alpha.

13 *** USER FATAL MESSAGE 13, DMAP INSTRUCTION NOT IN MODULE LIBRARY.

14 *** SYSTEM FATAL MESSAGE 14, ARRAY NAMED ***** OVERFLOWED.
See XGPI module description in MFD section of Programmer's Manual.

15 *** USER FATAL MESSAGE 15, INCONSISTENT LENGTH USED FOR PARAMETER NAMED *****.
This parameter was used in a previous DMAP instruction which gave it a different type.
See Section 5.2.1 of the User's Manual.

16 *** USER FATAL MESSAGE 16, ILLEGAL FORMAT.

17 *** USER FATAL MESSAGE 17, UNIDENTIFIED NASTRAN CARD KEYWORD *****.
FOLLOW ---

18 *** USER FATAL MESSAGE 18, TOO MANY PARAMETERS IN DMAP PARAMETER LIST.
Incorrect calling sequence for DMAP instruction.

19 *** USER FATAL MESSAGE 19, LABEL NAMED ***** IS MULTIPLY DEFINED.
LABEL named appears in more than one place in DMAP program.

20 *** USER FATAL MESSAGE 20, ILLEGAL CHARACTERS IN PARAMETER NO. ***
Name must be 8 or less alpha-numeric characters, the first character being alpha.

21 *** USER FATAL MESSAGE 21, PARAMETER NAMED ***** IS NOT IN PRECEDING DMAP INSTRUCTION
PARAMETER LIST.
Parameters in SAVE instruction must appear in immediately preceding DMAP instruction.

22 *** USER FATAL MESSAGE 22, DATA BLOCK NAMED ***** MUST BE DEFINED PRIOR TO THIS INSTRUCTION.
See Section 5.2 of the User's Manual.

DIAGNOSTIC MESSAGES

- 23 *** USER FATAL MESSAGE 23, DATA BLOCK NAMED ***** IS NOT REFERENCED IN SUBSEQUENT FUNCTIONAL MODULE.
See Section 5.2 of the User's Manual. Error can be suppressed by adding the following :
PARAM //C,N,NOP/V,N,TRUE=-1 \$
COND LABELXXX,TRUE \$
TABPT *****,,,// \$
LABEL LABELXXX \$
- 24 *** SYSTEM FATAL MESSAGE 24, CANNOT FIND FILE NAMED ***** ON DATA POOL TAPE.
Contents of /XDPL/ does not match contents of Pool Tape.
- 25 *** USER FATAL MESSAGE 25, PARAMETER NAMED ***** NOT DEFINED.
Parameter is referenced in nonfunctional module, but is nowhere defined.
- 26 *** USER FATAL MESSAGE 26, LABEL NAMED ***** NOT DEFINED.
LABEL name does not appear in LABEL instruction.
- 27 *** USER WARNING MESSAGE 27, LABEL NAMED ***** NOT REFERENCED.
LABEL name appears only in a LABEL instruction.
- 28 *** SYSTEM FATAL MESSAGE 28, UNEXPECTED END OF TAPE ON NEW PROBLEM TAPE.
Either you truly encountered an EOT or file linkage has been destroyed in /XFIST/, /XPFIST/ and/or /XXFIAT/.
- 29 *** SYSTEM FATAL MESSAGE 29, UNEXPECTED END OF TAPE ON OLD PROBLEM TAPE.
File linkage has been destroyed in /XFIST/, /XPFIST/ and/or /XXFIAT/.
- 30 *** SYSTEM FATAL MESSAGE 30, UNEXPECTED END OF TAPE ON DATA POOL TAPE.
See Message 28.
- 31 *** SYSTEM FATAL MESSAGE 31, CONTROL FILE ***** INCOMPLETE OR MISSING ON NEW PROBLEM TAPE.
Data block XCSA is not in correct format or it is missing.
- 32 *** USER FATAL MESSAGE 32, FILE NAMED ***** MUST BE DEFINED PRIOR TO THIS INSTRUCTION.
See Section 5.2 of the User's Manual.
- 33 *** SYSTEM FATAL MESSAGE 33, NAME (*****) IN NEW CONTROL FILE DICTIONARY NOT VALID.
First record of data block XCSA on Problem Tape contains a name which is not recognized by XGPI module.
- 34 *** SYSTEM FATAL MESSAGE 34, CANNOT TRANSLATE DMAP INSTRUCTION NO.***.
Error in subroutine XSCNDM or XRCARD.

NASTRAN SYSTEM AND USER MESSAGES

- 35 *** USER FATAL MESSAGE 35, INCORRECT OLD PROBLEM TAPE MOUNTED. ID OF TAPE MOUNTED = *****,
*****,**/**/** FILE =***. ID OF TAPE DESIRED = *****,*****,**/**/** FILE =***.
Wrong reel mounted for multireel Problem Tape.
- 36 *** SYSTEM FATAL MESSAGE 36, CANNOT FIND FILE NAMED ***** ON OLD PROBLEM TAPE.
Header record of file on Problem Tape does not match file name in restart dictionary.
- 37 *** USER WARNING MESSAGE 37, WARNING ONLY - MAY NOT BE ENOUGH FILES AVAILABLE FOR MODULE
REQUIREMENTS. FILES NEEDED = *** FILES AVAILABLE = ***.
Program will execute if enough data blocks referenced by the module are purged. Purged
data blocks are not assigned files.
- 38 *** SYSTEM FATAL MESSAGE 38, NOT ENOUGH CORE FOR GPI TABLES
User must break up DMAP program.
- 39 *** SYSTEM FATAL MESSAGE 39, RIGID FORMAT DMAP SEQUENCE DOES NOT CORRESPOND TO MED TABLE.
The MED Table must have the same number of entries as there are DMAP instructions in
DMAP sequence.
- 40 *** USER FATAL MESSAGE 40, ERROR IN ALTER DECK - CANNOT FIND END OF DMAP INSTRUCTION.
User should check ALTER part of the Executive Control Deck.
- 41 *** SYSTEM FATAL MESSAGE 41, TABLES INCORRECT FOR REGENERATING DATA BLOCK *****.
File Name Table and MED Table used by routine XFLDEF are wrong.
- 42 *** USER WARNING MESSAGE 42, PARAMETER NAMED ***** ALREADY HAD VALUE ASSIGNED PREVIOUSLY.
Parameter appears in a previous instruction which assigned it a value. The previous
value will be used.
- 43 *** USER FATAL MESSAGE 43, INCORRECT FORMAT FOR NASTRAN CARD.
- 44 *** USER FATAL MESSAGE 44, UNABLE TO FIND END DMAP INSTRUCTION.
User has altered out the END instruction.
- 45 *** USER FATAL MESSAGE 45, DATA BLOCK NAMED ***** ALREADY APPEARED AS OUTPUT OR WAS USED
AS INPUT BEFORE BEING DEFINED.
See Section 5.2 of the User's Manual.
- 46 *** USER FATAL MESSAGE 46, INCORRECT REENTRY POINT.
The last reentry card in the restart dictionary has a DMAP instruction number greater
than the instruction number on the END card of the DMAP program.
- 47 *** USER FATAL MESSAGE 47, THIS INSTRUCTION CANNOT BE FIRST INSTRUCTION OF LOOP.
CHKPNT DMAP instruction must not follow a LABEL instruction which is located at the top
of a loop.

DIAGNOSTIC MESSAGES

- 48 *** USER WARNING MESSAGE 48, DATA BLOCK ***** IS ALWAYS REGENERATED, THEREFORE IT WILL NOT BE CHECKPOINTED.
This data block is generated by Input File Processors (IFP) and must not be checkpointed to insure proper restart.
- 49 *** SYSTEM FATAL MESSAGE 49, MPL TABLE (MODULE PROPERTIES LIST) IS INCORRECT.
Error is in common block /XGP12/.
- 50 *** SYSTEM FATAL MESSAGE 50, CANNOT FIND JUMP OSCAR ENTRY NEEDED FOR THIS RESTART.
There must be a dummy JUMP instruction before every LABEL instruction at top of a loop for rigid formats.
- 51 *** SYSTEM FATAL MESSAGE 51, NOT ENOUGH OPEN CORE FOR XGP1BS ROUTINE.
Additional core memory is required.
- 52 *** SYSTEM FATAL MESSAGE 52, NAMED COMMON /XLINK/ IS TOO SMALL.
There must be one word in LINK table for every entry in MPL.
- 53 *** USER FATAL MESSAGE 53, INCORRECT FORMAT IN ABOVE CARD.
- 201 *** USER FATAL MESSAGE 201, REQUESTED BULK DATA DECK ***** , NOT ON USER MASTER FILE.
Requested UMF problem identification number not found on currently mounted UMF tape.
- 202 *** SYSTEM FATAL MESSAGE 202, UMF COULD NOT BE OPENED.
User Master File (UMF) not present (destroyed) in FIST.
- 203 *** SYSTEM FATAL MESSAGE 203, ILLEGAL FOR ON UMF.
User Master File (UMF) contains no records in requested file.
- 204 *** USER FATAL MESSAGE 204, COLD START, NO BULK DATA.
No data cards were found after the BEGIN BULK card. A blank card will satisfy this rule.
- 205 *** USER WARNING MESSAGE 205, COLD START, DELETE CARDS IGNORED.
Delete (/) cards were present and ignored within the Bulk Data Deck.
- 206 *** USER FATAL MESSAGE 206, PREVIOUS CONTINUATION MNEMONIC HAS A DUPLICATE.
Two or more continuation cards were found with column 2-8 identical.
- 207 *** USER INFO MESSAGE 207, BULK DATA NOT SORTED, XSORT WILL REORDER DECK.
Bulk Data Deck was not in alpha-numeric sort. Sorting will be performed. Sorting of large deck can be time consuming.
- 208 *** USER FATAL MESSAGE 208, PREVIOUS CARD IS A DUPLICATE PARENT.
Two or more cards were found with column 74-80 identical and a continuation card is present with that mnemonic (column 2-8).

NASTRAN SYSTEM AND USER MESSAGES

209 *** USER FATAL MESSAGE 209, PREVIOUS **** CONTINUATION CARDS HAVE NO PARENTS.

One or more continuation cards were found with a mnemonic (column 2-8) not matching any other card (column 74-80).

210 *** SYSTEM FATAL MESSAGE 210, SCRATCH COULD NOT BE OPENED.

One of the required scratch files was not present (destroyed) in FIST.

211 *** SYSTEM FATAL MESSAGE 211, ILLEGAL EOF ON SCRATCH.

A required scratch file was formatted improperly.

212 *** SYSTEM FATAL MESSAGE 212, ILLEGAL EOF ON ITAPE4.

Scratch file containing continuations was mispositioned.

213 *** SYSTEM FATAL MESSAGE 213, ILLEGAL EOF ON OPTH.

Old Problem Tape contained no bulk data (illegal format).

214 *** SYSTEM FATAL MESSAGE 214, OPTH COULD NOT BE OPENED.

Old Problem Tape (OPTH) not present (destroyed) in FIST.

215 *** SYSTEM FATAL MESSAGE 215, NPTH COULD NOT BE OPENED.

New Problem Tape (NPTH) not present (destroyed) in FIST.

216 *** SYSTEM FATAL MESSAGE 216, ILLEGAL INDEX.

FORTTRAN computed-G0-T0 has received an illogical value.

217 *** SYSTEM FATAL MESSAGE 217, ILLEGAL EOF ON ITAPE4.

NASTRAN SYSTEM AND USER MESSAGES

300 *** USER FATAL MESSAGE 300, DATA ERROR IN FIELD UNDERLINED.

(1)

A data error as described in the text has been detected by utility routine XRCARD or RCARD.

300 *** USER FATAL MESSAGE 300, INVALID DATA COLUMN 72.

(2)

Error in format of exponent.

300 *** USER FATAL MESSAGE 300, INTEGER DATA OUT OF MACHINE RANGE.

(3)

The limits are $2^{31}-1$ for IBM, $2^{59}-1$ for CDC and $2^{35}-1$ for UNIVAC.

300 *** USER FATAL MESSAGE 300, INVALID CHARACTER FOLLOWING INTEGER IN COLUMN ***.

(4)

Either an illegal delimiter was detected or a real number is missing the decimal.

300 *** USER FATAL MESSAGE 300, DATA ERROR - UNANTICIPATED CHARACTER IN COLUMN ***.

(5)

$A \pm E$ or $\pm D$ was expected based on other input data.

300 *** USER FATAL MESSAGE 300, DATA ERROR MISSING DELIMITER OR REAL POWER OUT OF MACHINE RANGE.

(6)

Either no delimiter was found or the power was exceeded. The limits are E-78 to E+75 for IBM, E-38 to E+38 for UNIVAC and E-294 to E+322 for CDC.

300 *** USER FATAL MESSAGE 300, ROUTINE XRCARD FINDS OUTPUT BUFFER TOO SMALL TO PROCESS CARD COMPLETELY.

(7)

301 *** USER WARNING MESSAGE 301, BULK DATA CARD ***** CONTAINS INCONSISTENT DATA.
SORTED CARD COUNT = *****

302 *** USER WARNING MESSAGE 302, ONE OR MORE GRID CARDS HAVE DISPLACEMENT COORDINATE SYSTEM ID OF -1.

303 *** SYSTEM FATAL MESSAGE 303, NO OPEN CORE FOR IFP.

Overlay structure must be redefined.

304 *** SYSTEM FATAL MESSAGE 304, IFP NOT READING NPTP **** *

The Input File Processor subroutine IFP attempts to locate the bulk data file on the NPTP by searching it forward. The first two words of the file header records are examined for a match with the Hollerith string BULKDATA. If the bulk data is not found by the fifth file, the assumption is made that IFP is either not reading NPTP or that it has been badly written. The header record of fifth file is printed as part of the message.

DIAGNOSTIC MESSAGES

- 305 *** SYSTEM FATAL MESSAGE 305, GINØ CANNØT ØPEN FILE *****.
Unexpected nonstandard return from ØPEN.
- 306 *** SYSTEM FATAL MESSAGE 306, READ LØGIC RECØRD ERRØR.
Short record encountered. Bulk data card images occupy 20 words.
- 307 *** USER FATAL MESSAGE 307, ILLEGAL NAME FØR BULK DATA CARD *****.
See Section 2.4 of the User's Manual.
- 308 *** USER FATAL MESSAGE 308, CARD ***** NØT ALLØWED IN ***** APPRØACH.
See Section 2.4 of the User's Manual.
- 309 *** USER WARNING MESSAGE 309, CARD ***** IMPRØPER IN ***** APPRØACH.
See Section 2.4 of the User's Manual.
- 310 *** USER FATAL MESSAGE 310, CARD ***** NØT ALLØWED IN SAME DECK AS AXIC CARD.
See Section 2.4 of the User's Manual.
- 311 *** USER FATAL MESSAGE 311, NØNUNIQUE FIELD 2 ØN BULK DATA CARD ***** ***.
Sorted bulk data card indicated must have a unique integer in field 2.
- 312 *** USER FATAL MESSAGE 312, TØØ MANY CØNTINUATIØNS FØR BULK DATA CARD *****.
See bulk data card description in Section 2.4 of the User's Manual.
- 313 *** USER FATAL MESSAGE 313, ILLEGAL NUMBER ØF WØRDS ØN BULK DATA CARD *****.
See bulk data card description in Section 2.4 of the User's Manual.
- 314 *** SYSTEM FATAL MESSAGE 314, INVALID CALL FRØM IFP *****.
Code error, machine failure, or cell is being destroyed.
- 315 *** USER FATAL MESSAGE 315, FØRMAT ERRØR ØN BULK DATA CARD *****.
See bulk data card description in Section 2.4 of the User's Manual.
- 316 *** USER FATAL MESSAGE 316, ILLEGAL DATA ØN BULK DATA CARD *****.
See bulk data card description in Section 2.4 of the User's Manual.
- 317 *** USER FATAL MESSAGE 317, BAD DATA ØR FØRMAT ØR NØN-UNIQUE NAME DTI **** SØRTED CARD
CØUNT ****.
See bulk data card description in Section 2.4 of the User's Manual.
- 318 *** SYSTEM FATAL MESSAGE 318, NØ RØØM IN /XDPL/ FØR DTI ****.
Overflow of Data Pool Table. See Section 2 of the Programmer's Manual.

NASTRAN SYSTEM AND USER MESSAGES

- 319 *** SYSTEM FATAL MESSAGE 319, IFP READING EOF ON NPTP.
Unexpected EOF encountered while attempting to read a card image.
- 320 *** USER FATAL MESSAGE 320, IFP ERROR ***** LAST CARD PROCESSED IS *****.
Code error in IFP or XSORT.
- 321 *** USER FATAL MESSAGE 321, NONUNIQUE PARAM NAME *****.
All names of parameters must be unique.
- 322 *** SYSTEM FATAL MESSAGE 322, ILLEGAL ENTRY TO IFSIP.
IFP code error detected in IFSIP, IFS2P, IFS3P, IFS4P, IFS5P.
- 324 *** USER WARNING MESSAGE 324, BLANK CARD(S) IGNORED.
Blank bulk data cards are ignored by NASTRAN.
- 325 *** USER FATAL MESSAGE 325, BAD DATA OR FORMAT OR NONUNIQUE NAME. DMI *****.
See bulk data card description in Section 2.4 of the User's Manual.
- 326 *** SYSTEM FATAL MESSAGE 326, NO ROOM IN /XDPL/ FOR DMI *****.
Overflow of Data Pool Table. See Section 2 of the Programmer's Manual.
- 327 *** USER FATAL MESSAGE 327, BAD DATA OR FORMAT OR NONUNIQUE NAME. DMIG *****.
See bulk data card description in Section 2.4 of the User's Manual.
- 328 *** SYSTEM FATAL MESSAGE 328, ILLEGAL ENTRY TO IFS3P.
IFP code error.
- 329 *** USER FATAL MESSAGE 329, ONLY ONE (1) AXIC CARD ALLOWED.
See bulk data card description in Section 2.4 of the User's Manual.
- 330 *** SYSTEM FATAL MESSAGE 330, NO ROOM IN CORE FOR PARAM CARDS.
Change overlay or increase core size.
- 331 *** USER FATAL MESSAGE 331, IMPROPER PARAM CARD *****.
See bulk data card description in Section 2.4 of the User's Manual.
- 332 *** USER FATAL MESSAGE 332, AXIC CARD REQUIRED.
The presence of any conical shell data cards requires the presence of an AXIC card.
See the AXIC bulk data card description in Section 2.4 of the User's Manual.
- 501 *** SYSTEM FATAL MESSAGE 501, MED TABLE INCORRECT FOR THIS SOLUTION.
Input to subroutine XSBSET is incorrect. Look for format error in array SS.

DIAGNOSTIC MESSAGES

- 502 *** USER FATAL MESSAGE 502, ILLEGAL SUBSET NUMBER FOR THIS SOLUTION.
User specified an incorrect subset number on SOL control card.
- 503 *** USER FATAL MESSAGE 503, ILLEGAL SOLUTION NUMBER.
User specified an incorrect solution number on SOL control card.
- 504 *** USER FATAL MESSAGE 504, CANNOT CHANGE FROM SOLUTION *** TO SOLUTION ***.
- 505 *** USER FATAL MESSAGE 505, CONTROL CARD **** IS ILLEGAL.
Card preceding Message 505 cannot be processed correctly.
- 506 *** USER FATAL MESSAGE 506, CONTROL CARD **** DUPLICATED.
Card preceding Message 506 cannot be input more than once.
- 507 *** USER FATAL MESSAGE 507, ILLEGAL SPECIFICATION OR FORMAT ON PRECEDING CARD.
- 508 *** USER FATAL MESSAGE 508, PROBLEM TAPE MUST BE ON PHYSICAL TAPE FOR CHECKPOINTING.
User requested checkpointing (i.e., CHPNT YES) therefore Problem Tape must be setup on tape drive.
- 509 *** USER FATAL MESSAGE 509, WRONG OLD PROBLEM TAPE MOUNTED. OLD PROBLEM TAPE ID = *****,
*****,**/**/, REEL NO. = ***.
The Old Problem Tape identification does not match the identification on the RESTART restart card.
- 510 *** SYSTEM FATAL MESSAGE 510, CHECKPOINT DICTIONARY EXCEEDS CORE SIZE - REMAINING RESTART CARDS IGNORED.
You have run out of open core. If approach is DMAP try putting restart deck before DMAP sequence. If this does not solve problem, or if approach is not DMAP, then you must decrease size of restart deck.
- 511 *** SYSTEM FATAL MESSAGE 511, DMAP SEQUENCE EXCEEDS CORE SIZE - REMAINING DMAP INSTRUCTIONS IGNORED.
You have run out of open core. Split the DMAP sequence somewhere prior to where Message 511 was printed out.
- 512 *** USER FATAL MESSAGE 512, OLD PROBLEM TAPE IS MISSING AND IS NEEDED FOR RESTART.
The Problem Tape corresponding to identification on RESTART control card must be setup on the unit assigned to the Old Problem Tape.
- 513 *** USER FATAL MESSAGE 513, ALTER SEQUENCE NUMBERS ARE OUT OF ORDER.
- 514 *** USER FATAL MESSAGE 514, ENDALTER CARD IS MISSING.
Alter deck must end with ENDALTER control card.
- 515 *** USER FATAL MESSAGE 515, END INSTRUCTION MISSING IN DMAP SEQUENCE.
DMAP sequence must end with END control card.

NASTRAN SYSTEM AND USER MESSAGES

516 *** USER FATAL MESSAGE 516, UMF TAPE MUST BE MOUNTED ON PHYSICAL TAPE DRIVE.

The UMF tape must be setup on the unit assigned to it.

517 *** USER FATAL MESSAGE 517, WRONG UMF TAPE MOUNTED - TAPE ID = ****.

The tape identification number on the UMF tape does not match the tape identification number on the UMF control card.

518 *** USER FATAL MESSAGE 518, CANNOT USE UMF TAPE FOR RESTART.

519 *** USER FATAL MESSAGE 519, ID CARD MUST PRECEDE ALL OTHER CONTROL CARDS.

520 *** USER FATAL MESSAGE 520, CONTROL CARD **** IS MISSING.

The control card mentioned is required for this problem.

521 *** USER FATAL MESSAGE 521, SPECIFY A SOLUTION OR A DMAP SEQUENCE BUT NOT BOTH.

You must either select a DMAP sequence from the library by using the SOL control card or by supplying your own DMAP sequence. Do one or the other, but not both.

522 *** USER FATAL MESSAGE 522, NEITHER A SOL CARD NOR A DMAP SEQUENCE WAS INCLUDED.

See Message 521.

523 *** USER FATAL MESSAGE 523, ENDALTER CARD OUT OF ORDER.

ENDALTER control card must be preceded by the ALTER DECK.

524 *** SYSTEM FATAL MESSAGE 524, ALTERNATE RETURN TAKEN WHEN OPENING FILE ****.

This occurs if file name is not in FIST or the end of tape was reached while writing on the file. The file name should correspond to one of the permanent entries in the FIST.

525 *** SYSTEM FATAL MESSAGE 525, ILLEGAL FORMAT ENCOUNTERED WHILE READING FILE ****.

File is not in the correct format. Either the wrong tape was mounted or it does not contain what you think it should.

526 *** USER FATAL MESSAGE 526, CHECKPOINT DICTIONARY OUT OF SEQUENCE - REMAINING RESTART CARDS IGNORED.

The checkpoint dictionary which follows the RESTART control card must be sequenced according to first number on each card.

527 *** USER FATAL MESSAGE 527, DUPLICATE SUBSET NUMBER *****.

DIAGNOSTIC MESSAGES

601 *** USER FATAL MESSAGE 601, THE KEYWORD ON THE ABOVE CARD IS ILLEGAL OR MISSPELLED.
SEE THE FOLLOWING LIST FOR LEGAL KEYWORDS.

Case control expects each card to begin with a keyword (usually 4 characters in length). Your card does not. User Message 612 will list the legal keywords along with a brief description of function. To remove the error, consult Message 612 or NASTRAN case control card descriptions, User's Manual Section 2.3, and spell your request correctly.

602 *** USER WARNING MESSAGE 602, TWO OR MORE OF THE ABOVE CARD TYPES DETECTED WHERE ONLY ONE IS LEGAL. THE LAST FOUND WILL BE USED.

Remove the card with the duplicate meaning. Note that some cards have alternate forms.

NASTRAN SYSTEM AND USER MESSAGES

- 603 *** USER FATAL MESSAGE 603, THE ABOVE CARD DOES NOT END PROPERLY. COMMENTS SHOULD BE PRECEDED BY A DOLLAR SIGN.
Case control cards of the form, name = value, should not contain more than one value. Consult your NASTRAN Case Control Deck document, User's Manual Section 2.3, for a complete description of the card or precede your comments with a dollar sign.
- 604 *** USER FATAL MESSAGE 604, THE ABOVE CARD HAS A NONINTEGER IN AN INTEGER FIELD.
Consult your NASTRAN Case Control Deck document, User's Manual Section 2.3, for legal values.
- 605 *** USER FATAL MESSAGE 605, A SYMSEQ OR SUBSEQ CARD APPEARS WITHOUT A SYMCOM OR SUBCOM CARD.
SYMSEQ or SUBSEQ cards must appear in a subcase defined by a SYMCOM or SUBCOM card. Check your Case Control Deck order and relabel your combination subcase.
- 606 *** USER FATAL MESSAGE 606, A REQUEST FOR TEMPERATURE DEPENDENT MATERIALS OCCURS AT THE SUBCASE LEVEL. ONLY ONE ALLOWED PER PROBLEM.
Only one temperature field for materials is allowed per NASTRAN run. The last specified will be used for the entire run. If additional ones are desired, a modified restart is in order.
- 607 *** USER FATAL MESSAGE 607, A REPCASE SUBCASE MUST BE PRECEDED BY A SUBCASE OR SYM SUBCASE.
A REPCASE subcase is an attempt to reoutput the previously computed case, therefore it cannot be the first subcase.
- 608 *** USER FATAL MESSAGE 608, THE SET ID SPECIFIED ON THE ABOVE CARD MUST BE DEFINED PRIOR TO THIS CARD.
Set identification numbers must be specified prior to their use. Also sets specified within a subcase die at the end of the subcase. Redefine set (or define set) or move set out of subcase.
- 609 *** USER FATAL MESSAGE 609, SUBCASE DELIMITER CARDS MUST HAVE A UNIQUE IDENTIFYING INTEGER.
Subcase type cards must have an identifying integer. These numbers must be strictly increasing. Renumber your subcase cards. The use of a nonblank delimiter (e.g., "=") will also cause this message to occur.
- 610 *** USER FATAL MESSAGE 610, THE VALUE FOLLOWING THE EQUAL SIGN IS ILLEGAL.
Case control cannot identify the BCD value after the equal sign. Consult NASTRAN case control card descriptions, User's Manual Section 2.3, for a full description of the card.
- 611 *** USER FATAL MESSAGE 611, TEN CARDS HAVE ILLEGAL KEY WORDS. NASTRAN ASSUMES BEGIN BULK CARD IS MISSING. IT WILL NOW PROCESS YOUR BULK DATA.
Only ten key words may be misspelled. A common source of this error may be the omission of the OUTPUT(PL0T) or OUTPUT(XY0UT) delimiter cards.
- 612 *** USER FATAL MESSAGE 612, --LIST OF LEGAL CASE CONTROL MNEMONICS.
This message is caused by Messages 601 or 611.

NASTRAN SYSTEM AND USER MESSAGES

- 513 *** USER FATAL MESSAGE 613, THE ABOVE SET CONTAINS 'EXCEPT' WHICH IS NOT PRECEDED BY 'THRU'.
Only identification numbers included in THRU statements may be excepted. Simplify your SET request.
- 614 *** USER FATAL MESSAGE 614, THE ABOVE SET IS BADLY SPECIFIED.
The grammar of the SET list is so confused that IFP1 cannot continue. Simplify the SET list.
- 615 *** USER FATAL MESSAGE 615, AN IMPROPER OR NO NAME GIVEN TO THE ABOVE SET.
SET lists must have integer names. This SET list does not have one. SET 10 = is the correct format. Give the SET a correct integer name.
- 616 *** USER FATAL MESSAGE 616, 'EXCEPT' CANNOT BE FOLLOWED BY 'THRU'. LIST EXPLICITLY ALL EXCEPTIONS.
EXCEPT in SET list can only be followed by integers. An integer larger than THRU pair terminates THRU. Either list exceptions explicitly, use 2 'THRU's or terminate first THRU.
- 617 *** USER FATAL MESSAGE 617, A NONPOSITIVE INTEGER APPEARS IN A POSITIVE POSITION.
Most integer values in case control must be positive. The above card either has a negative integer or a BCD value in a positive position. Check the Case Control Deck documentation in Section 2.3 of the User's Manual for the proper card format.
- 618 *** USER FATAL MESSAGE 618, PLOTTER OUTPUT IS REQUESTED BUT NO PLOT TAPE IS SET UP.
Neither PLT1 or PLT2 is a physical tape. Remove the plot control packet or set up the appropriate tape.
- 619 *** USER WARNING MESSAGE 619, SET MEMBER *** BELONGS TO *** THRU ***.
A set member is already included in a THRU. The individual member will be absorbed in the THRU.
- 620 *** USER WARNING MESSAGE 620, DUPLICATE *** IS IN SET LIST.
A set member is listed twice. The second reference will be deleted.
- 621 *** USER WARNING MESSAGE 621, INTERVAL *** THRU *** OVERLAPS INTERVAL *** THRU ***. THE MAXIMUM INTERVAL WILL BE USED.
- 625 *** USER FATAL MESSAGE 625, SUBCASE ID'S MUST BE LESS THAN 99,999,999.
Reduce the size of your subcase identification number. Note also that BCD subcase identification numbers are not legal.
- 626 *** USER FATAL MESSAGE 626, SUBCOM SUBCASE DOES NOT HAVE A SUBSEQ CARD.
A SUBCOM SUBCASE must contain a SUBSEQ card to define the linear combination coefficients.

DIAGNOSTIC MESSAGES

627 *** USER FATAL MESSAGE 627, THE ABOVE SUBCASE HAS BOTH A STATIC LOAD AND A REAL EIGENVALUE METHOD SELECTION -- REMOVE ONE.

The Buckling Rigid Format (5) requires two subcases: one for Statics and one for Buckling. Both a load and a method selection cannot take place in the same subcase.

628 *** USER FATAL MESSAGE 628, THERMAL, DEFORMATION, AND EXTERNAL LOADS CANNOT HAVE THE SAME SET IDENTIFICATION NUMBER.

Set id's specified on the LOAD, TEMP (LOAD), and DEFORM Case Control Cards must be unique.

629 *** USER WARNING MESSAGE 629, ECHO CARD HAS REPEATED OR UNRECOGNIZABLE SPECIFICATION DATA- REPEATED SPECIFICATIONS WILL BE IGNORED, UNRECOGNIZABLE SPECIFICATIONS WILL BE TREATED AS SORT.

675 *** USER FATAL ERROR MESSAGE 675, ABOVE CARD DOES NOT BEGIN WITH A NONNUMERIC WORD.

676 *** USER FATAL ERROR MESSAGE 676, **** IS NOT RECOGNIZED ON ABOVE CARD.

677 *** USER FATAL ERROR MESSAGE 677, ILLEGAL VALUE SPECIFIED.

678 *** USER FATAL ERROR MESSAGE 678, *** CONTRADICTS PREVIOUS DEFINITION.

679 *** USER FATAL ERROR MESSAGE 679, *** DELIMITER ILLEGALLY USED.

680 *** USER FATAL ERROR MESSAGE 680, **** ILLEGAL IN STATEMENT.

681 *** USER FATAL ERROR MESSAGE 681, **** IS ILLEGAL IN STATEMENT.

682 *** USER FATAL ERROR MESSAGE 682, **** IS ILLEGAL IN STATEMENT.

683 *** USER FATAL ERROR MESSAGE 683, TOO MANY SUBCASES. MAXIMUM = 200 ON ANY ONE XY-OUTPUT COMMAND CARD.

684 *** USER FATAL ERROR MESSAGE 684, SUBCASE-ID IS LESS THAN 1 OR IS NOT IN ASCENDING ORDER.

685 *** USER FATAL ERROR MESSAGE 685, **** = POINT OR ELEMENT ID IS ILLEGAL (LESS THAN 1).

686 *** USER FATAL ERROR MESSAGE 686, NEGATIVE OR ZERO COMPONENTS ARE ILLEGAL.

687 *** USER FATAL ERROR MESSAGE 687, ALPHA-COMPONENTS ARE NOT PERMITTED FOR STRESS OR FORCE XY-OUTPUT REQUESTS.

688 *** USER FATAL ERROR MESSAGE 688, **** COMPONENT NAME NOT RECOGNIZED.

689 *** USER FATAL ERROR MESSAGE 689, LAST CARD ENDED WITH A DELIMITER BUT NO CONTINUATION CARD WAS PRESENT.

NASTRAN SYSTEM AND USER MESSAGES

- 690 *** USER FATAL ERROR MESSAGE 690, TYPE OF CURVE WAS NOT SPECIFIED. (E.G. DISPLACEMENT, STRESS, ETC.).
- 691 *** USER FATAL ERROR MESSAGE 691, MORE THAN 2 OR UNEQUAL NUMBER OF COMPONENTS FOR IDENTIFICATION NUMBERS WITHIN A SINGLE FRAME.
- 692 *** USER FATAL ERROR MESSAGE 692, XY-OUTPUT COMMAND IS INCOMPLETE.
- 693 *** USER FATAL ERROR MESSAGE 693, INSUFFICIENT CORE FOR SET TABLE.
- 694 *** USER FATAL ERROR MESSAGE 694, AUTO OR PSDF REQUESTS MAY NOT USE SPLIT FRAME, THUS ONLY ONE COMPONENT PER ID IS PERMITTED.
- 695 *** USER FATAL ERROR MESSAGE 695, COMPONENT VALUE = **** IS ILLEGAL FOR AUTO OR PSDF VECTOR REQUESTS.
- 696 *** USER FATAL MESSAGE 696, COMPONENT VALUE = ***** IS ILLEGAL FOR VECTOR TYPE SPECIFIED.
- 969 *** USER FATAL ERROR MESSAGE 969, COMPONENT VALUE = **** IS ILLEGAL FOR VECTOR TYPE SPECIFIED.
- 975 *** USER WARNING MESSAGE 975, XYTRAN DOES NOT RECOGNIZE **** AND IS IGNORING:
- 976 *** USER WARNING MESSAGE 976, OUTPUT DATA BLOCK **** IS PURGED. XYTRAN WILL PROCESS ALL REQUESTS OTHER THAN PLOT.
- 977 *** USER WARNING MESSAGE 977, FOLLOWING NAMED DATA BLOCK IS NOT IN SORT2 FORMAT.
- 978 *** USER WARNING MESSAGE 978, XYTRAN MODULE FINDS DATA BLOCK (****) PURGED, NULL, OR INADEQUATE, AND IS IGNORING XY-OUTPUT REQUEST FOR - **** - CURVES.
- 979 *** USER WARNING MESSAGE 979, AN XY-OUTPUT REQUEST FOR POINT OR ELEMENT ID **** - **** - CURVE IS BEING PASSED OVER. THE ID COULD NOT BE FOUND IN DATA BLOCK ****.
- 980 *** USER WARNING MESSAGE 980, INSUFFICIENT CORE TO HANDLE ALL DATA FOR ALL CURVES OF THIS FRAME ID = **** COMPONENT = **** DELETED FROM OUTPUT.
- 981 *** USER WARNING MESSAGE 981, COMPONENT = **** FOR ID = **** IS TOO LARGE. THIS COMPONENTS CURVE NOT OUTPUT.
- 982 *** USER WARNING MESSAGE 982, FORMAT OF SDR3 INPUT DATA BLOCK **** DOES NOT PERMIT SUCCESSFUL SORT2 PROCESSING.
- 983 *** USER WARNING MESSAGE 983, SDR3 HAS INSUFFICIENT CORE TO PERFORM SORT2 ON INPUT DATA BLOCK **** OR DATA BLOCK IS NOT IN CORRECT FORMAT.

DIAGNOSTIC MESSAGES

- 984 *** USER WARNING MESSAGE 984, SDR3 FINDS OUTPUT DATA BLOCK **** PURGED.
- 985 *** USER WARNING MESSAGE 985, SDR3 FINDS SCRATCH **** PURGED.
- 986 *** USER WARNING MESSAGE 986, INSUFFICIENT CORE FOR SDR3.
- 991 *** USER WARNING MESSAGE 991, XYPLØT INPUT DATA FILE **** NOT FOUND. XYPLØT ABANDØNED.
The input data file probably has been purged and there were no plots to be done.
- 992 *** USER WARNING MESSAGE 992, XYPLØT INPUT DATA FILE I.D. RECORDS TOO SHORT. XYPLØT ABANDØNED.
The input data file records have invalid word counts and further plotting is not feasible.
- 993 *** USER WARNING MESSAGE 993, XYPLØT FOUND ØDD NO. OF VALUES FOR DATA PAIRS IN FRAME ****, CURVE NO. ****. LAST VALUE IGNØRED.
May indicate a bad input file, but plotting continues.
- 994 *** USER WARNING MESSAGE 994, XYPLØT ØUTPUT FILE NAME **** NOT FOUND. XYPLØT ABANDØNED.
A magnetic tape for plotting has not been properly set up and further plotting is useless.
- 995 *** USER WARNING MESSAGE 995, XYPLØT HAS ILLEGAL PLØTTER NUMBER = **** FROM INPUT DATA FILE. PLØTTER NO. **** ASSUMED.
Probable cause is the user not setting up the proper plotter number in the Case Control Deck. The plotting will be done on the plotter most commonly used at the installation.
- 996 *** USER WARNING MESSAGE 996, SPECIFIED PLØTTER PAPER SIZE TOO SMALL. XYPLØT ASSUMES DIMENSION IS 8 INCHES.
Message is for table plotter only. Assumption is made that plotter paper will be at least as large as stated. In any event the table plotter will have an inch margin on all sides.
- 997 *** USER WARNING MESSAGE 997, NO. ***. FRAME NO. **** INPUT DATA INCOMPATIBLE. ASSUMPTIONS MAY PRODUCE INVALID PLØT.
NO. *** may take any value from 1 to 4 with the following meaning:
1. Specified X maximum equal X minimum. If this value is zero, then X maximum is set to 5.0 and X minimum to -5.0, otherwise 5 times the absolute value of X maximum is added to X maximum and subtracted from X minimum.
 2. Specified X maximum is smaller than X minimum. The values are reversed.
 3. Same meaning as number 1 except for Y maximum and Y minimum.
 4. Same meaning as number 2 except for Y maximum and Y minimum.

NASTRAN SYSTEM AND USER MESSAGES

6.2.2 Executive Module Messages

- 1001 *** SYSTEM FATAL MESSAGE 1001, ØSCAR NOT FOUND IN DPL.
ØSCAR file not present (destroyed) in Data Pool Dictionary.
- 1002 *** SYSTEM FATAL MESSAGE 1002, ØSCAR CONTAINS NO MODULES.
XSFA found no modules on ØSCAR needing file allocation.
- 1003 *** SYSTEM FATAL MESSAGE 1003, PØØL COULD NOT BE ØPENED.
Data Pool File (PØØL) not present (destroyed) in FIST.
- 1004 *** SYSTEM FATAL MESSAGE 1004, ILLEGAL EOF ON PØØL.
End-Of-File encountered before ØSCAR file reached on Data Pool.
- 1011 *** SYSTEM FATAL MESSAGE 1011, MD ØR SØS TABLE ØVERFLØW.
Module description or serial ØSCAR table overflowed.
- 1012 *** SYSTEM FATAL MESSAGE 1012, PØØL COULD NOT BE ØPENED.
Data Pool File (PØØL) not present (destroyed) in FIST.
- 1013 *** SYSTEM FATAL MESSAGE 1013, ILLEGAL EOF ON PØØL.
ØSCAR record has illegal format.
- 1014 *** SYSTEM FATAL MESSAGE 1014, PØØL FILE MIS-POSITIONED.
ØSCAR (PØØL) file not at position passed in XSFA calling sequence.
- 1021 *** SYSTEM FATAL MESSAGE 1021, FIAT ØVERFLØWED.
FIAT /XFIAT/ Table overflowed - reduce number of logical files. See Section 2 of the Programmer's Manual.
- 1031 *** SYSTEM FATAL MESSAGE 1031, DPL ØVERFLØW.
Data Pool Dictionary /XDPL/ overflowed - increase compiled size. See Section 2 of the Programmer's Manual.
- 1032 *** SYSTEM FATAL MESSAGE 1032, PØØL ØR FILE BEING PØØLED/UN-PØØLED COULD NOT BE ØPENED.
Files not present (destroyed) in FIST.
- 1033 *** SYSTEM FATAL MESSAGE 1033, ILLEGAL EOF ON FILE BEING PØØLED.
File being pooled has illegal format.
- 1034 *** SYSTEM FATAL MESSAGE 1034, ILLEGAL EOF ON FILE BEING PØØLED.
File being pooled has illegal format (bad header).

DIAGNOSTIC MESSAGES

- 1035 *** SYSTEM FATAL MESSAGE 1035, EQUIV INDICATED, NONE FOUND.
File (data block) equivalence not found as indicated by XSFA.
- 1041 *** SYSTEM FATAL MESSAGE 1041, OLD/NEW POOL COULD NOT BE OPENED.
Files not present (destroyed) in FIST.
- 1051 *** SYSTEM FATAL MESSAGE 1051, FIAT OVERFLOW.
FIAT /XFIAT/ overflowed - reduce number of logical files. See Section 2 of the Programmer's Manual.
- 1101 *** USER FATAL MESSAGE 1101, COULD NOT OPEN FILE NAMED *****.
Data block has not been generated.
- 1102 *** SYSTEM FATAL MESSAGE 1102, COULD NOT OPEN FILE NAMED *****.
Problem Tape (NPTP) or Pool Table (POOL) File linkage is broken. Look for error in /XFIST/, /XPFIST/ or /XXFIAT/.
- 1103 *** SYSTEM FATAL MESSAGE 1103, UNABLE TO POSITION DATA POOL FILE CORRECTLY.
Contents of /XDPL/ does not correspond to contents of POOL file.
- 1104 *** SYSTEM FATAL MESSAGE 1104, FDICT TABLE IS INCORRECT.
Subroutine XCHK is not generating FDICT correctly.
- 1105 *** USER FATAL MESSAGE 1105, CANNOT FIND DATA BLOCK NAMED ***** HEADER RECORD = *****.
Data block name or equivalenced data block name must match header record.
- 1106 *** USER FATAL MESSAGE 1106, CHECKPOINT DICTIONARY OVERFLOWED THERE IS NO MORE CORE AVAILABLE.
Restart problem from this point with dictionary available.
- 1107 *** SYSTEM FATAL MESSAGE 1107, CANNOT FIT DATA BLOCK NAMED ***** ON TWO PROBLEM TAPE REELS.
Use full tape reels for Problem Tape.
- 1108 *** SYSTEM FATAL MESSAGE 1108, PURGE TABLE OVERFLOWED.
Reduce the number of data blocks being checkpointed at one time by replacing a single CHKPT instruction with two CHKPT instructions .
- 1109 *** SYSTEM FATAL MESSAGE 1109, CANNOT FIND DATA BLOCK NAMED NXPTDC HEADER RECORD = *****.
Problem Tape is not positioned correctly for reading NXPTDC. Problem is in subroutine which previously wrote NXPTDC onto Problem Tape. Suspect modules are XGPI, XCEI or XCHK.

NASTRAN SYSTEM AND USER MESSAGES

- 1126 *** SYSTEM FATAL MESSAGE 1126, ADDRESS OF BUFFER LESS THAN ADDRESS OF /XNSTRN/.
Highly unlikely. Program bug or machine error.
- 1127 *** SYSTEM FATAL MESSAGE 1127, BUFFER ASSIGNED EXTENDS INTO MASTER INDEX AREA.
Calling program bug in buffer allocation or first word of /SYSTEM/ has been altered.
- 1128 *** SYSTEM FATAL MESSAGE 1128, ON AN OPEN CALL WITHOUT REWIND, THE BLOCK NUMBER READ DOES NOT MATCH EXPECTED VALUE.
Probable I/O error.
- 1129 *** SYSTEM FATAL MESSAGE 1129, ON A CALL WRITE THE WORD COUNT IS NEGATIVE.
Definite calling program error.
- 1130 *** SYSTEM FATAL MESSAGE 1130, ON A CALL READ THE CONTROL WORD AT WHICH THE FILE IS POSITIONED IS NOT ACCEPTABLE.
Attempt to read string formatted record which is not allowed.
- 1131 *** SYSTEM FATAL MESSAGE 1131, LOGICAL RECORD TRAILER NOT RECOGNIZABLE AS SUCH.
Probable GINØ bug or hardware error.
- 1132 *** SYSTEM FATAL MESSAGE 1132, UNRECOGNIZABLE CONTROL WORD DURING PROCESSING OF A BCKREC CALL.
Probable GINØ bug or hardware error.
- 1133 *** SYSTEM FATAL MESSAGE 1133, AFTER A POSITIONING CALL TO IØ6600, DURING PROCESSING OF A BCKREC CALL THE BLOCK READ WAS NOT THE EXPECTED ONE.
Probable IØ6600 bug or possible I/O error.
- 1134 *** SYSTEM FATAL MESSAGE 1134, CALL SKPFIL IN A FORWARD DIRECTION ON A FILE NOT OPENED FOR OUTPUT IS NOT SUPPORTED.
- 1135 *** SYSTEM FATAL MESSAGE 1135, FILPOS WAS CALLED ON A FILE OPENED FOR OUTPUT.
- 1136 *** SYSTEM FATAL MESSAGE 1136, ENDPUT WAS CALLED WITH BLOCK (8) = -1.
Most likely PUTSTR was not called first.
- 1137 *** SYSTEM FATAL MESSAGE 1137, MORE TERMS WRITTEN IN STRING THAN WERE AVAILABLE TO WRITE.
Most likely subroutine logic error.
- 1138 *** SYSTEM FATAL MESSAGE 1138, CURRENT BUFFER POINTER EXCEEDS LAST DATA WORD IN BLOCK.
Probably a bug in PUTSTR in the computation of the number of terms available to write in a string.

DIAGNOSTIC MESSAGES

1139 *** SYSTEM FATAL MESSAGE 1139, ON AN INITIAL CALL TO GETSTR, THE RECORD IS NOT POSITIONED AT THE COLUMN HEADER.

Either the record is not a string formatted record, or the calling routine has not made a proper sequence of GETSTR, ENDGET calls.

1140 *** SYSTEM FATAL MESSAGE 1140, STRING DEFINITION WORD NOT RECOGNIZABLE.

Probable cause is a failure to call ENDGET to complete processing of the previous string.

1141 *** SYSTEM FATAL MESSAGE 1141, FIRST WORD OF A DOUBLE PRECISION STRING IS NOT ON A DOUBLE PRECISION BOUNDARY.

This error is probably due to a bug in any of PUTSTR, OPEN or NASTI, all of which have responsibility for insuring proper alignment.

1142 *** SYSTEM FATAL MESSAGE 1142, CURRENT BUFFER POINTER IS BEYOND RANGE OF INFORMATION IN BUFFER.

Either an attempt to read beyond end-of-information or a GINO logic bug.

1143 *** SYSTEM FATAL MESSAGE 1143, ON AN INITIAL CALL TO GETSTB, THE FILE IS NOT POSITIONED AT AN ACCEPTABLE POINT.

File should be positioned at a beginning of record or end-of-file.

1144 *** SYSTEM FATAL MESSAGE 1144, END-OF-SEGMENT CONTROL WORD SHOULD HAVE IMMEDIATELY PRECEDED CURRENT POSITION AND IT DID NOT.

GINO logic error.

1145 *** SYSTEM FATAL MESSAGE 1145, COLUMN TRAILER NOT FOUND.

Previous record to be read backwards is not a string formatted record.

1146 *** SYSTEM FATAL MESSAGE 1146, PREVIOUS RECORD TO BE READ BACKWARDS WAS NOT WRITTEN WITH STRING TRAILERS.

1147 *** SYSTEM FATAL MESSAGE 1147, STRING RECOGNITION WORD NOT RECOGNIZED.

A subroutine may not have called GETSTB to indicate completion of processing of previous string or a bug in GETSTB logic.

1148 *** SYSTEM FATAL MESSAGE 1148, RECORD CONTROL WORD NOT IN EXPECTED POSITION.

Logic error in GETSTB or PUTSTR when string was written.

1149 *** SYSTEM FATAL MESSAGE 1149, RECTYP WAS CALLED FOR A FILE OPENED FOR OUTPUT.

Not allowed.

NASTRAN SYSTEM AND USER MESSAGES

- 1150 *** SYSTEM FATAL MESSAGE 1150, RECTYP MUST BE CALLED WHEN THE FILE IS POSITIONED AT THE BEGINNING OF A RECORD.
- 1151 *** SYSTEM FATAL MESSAGE 1151, ON A CALL TO OPEN THE BUFFER ASSIGNED OVERLAPS A PREVIOUSLY ASSIGNED BUFFER.
- 1152 *** SYSTEM FATAL MESSAGE 1152, CALL TO OPEN FOR AN ALREADY OPEN FILE.
- 1153 *** SYSTEM FATAL MESSAGE 1153, FILE NOT OPEN.
- 1154 *** SYSTEM FATAL MESSAGE 1154, GINØ REFERENCE NAME NOT IN LIST OR FILE NOT OPEN.
- 1155 *** SYSTEM FATAL MESSAGE 1155, CALL TO GETSTR OCCURRED WHEN THE FILE WAS POSITIONED AT END-OF-FILE.
- 1156 *** SYSTEM FATAL MESSAGE 1156, ATTEMPTED TO WRITE ON AN INPUT FILE.
- 1157 *** SYSTEM FATAL MESSAGE 1157, ATTEMPTED TO READ FROM AN OUTPUT FILE.
- 1158 *** SYSTEM FATAL MESSAGE 1158, A CALL TO BLDPK OR PACK IN WHICH EITHER TYPIN OR TYPØUT IS OUT OF RANGE.
- 1159 *** SYSTEM FATAL MESSAGE 1159, ROW POSITIONS OF ELEMENTS FURNISHED TO ZBLPKI OR BLDPKI ARE NOT IN MONOTONIC INCREASING SEQUENCE.
- 1160 *** SYSTEM FATAL MESSAGE 1160, ON A CALL TO BLDPKN, FILE NAME DOES NOT MATCH PREVIOUS CALLS.
BLDPK was not called prior to call to BLDPKN.
- 1161 *** SYSTEM FATAL MESSAGE 1161, A CALL TO INTPK OR UNPACK IN WHICH TYPØUT IS OUT OF RANGE.
- 1162 *** SYSTEM FATAL MESSAGE 1162, ON AN ATTEMPT TO READ A SUBINDEX AT THE TIME OF A CALL TO OPEN AN END-OF-FILE WAS ENCØUNTERED OR WRONG NUMBER OF WORDS READ.
The file has never been written and IØ6600 failed to detect it; possible I/Ø error.
- 1163 *** SYSTEM FATAL MESSAGE, A READ ATTEMPT WHEN THE CORRESPONDING SUBINDEX IS ZERO.
Normally this indicates an attempt to read past the end-of-information. However, if called from FILPOS, suspect is subroutine error in saving and returning a correct file position.
- 1164 *** SYSTEM FATAL MESSAGE, FOLLOWING A READ ATTEMPT ON AN INDEXED FILE, EITHER AN END-OF-FILE WAS ENCØUNTERED OR THE NUMBER OF WORDS READ WAS INCØRRECT.
I/Ø error.

DIAGNOSTIC MESSAGES

- 1165 *** SYSTEM FATAL MESSAGE 1165, ON AN ATTEMPT TO READ A SEQUENTIAL FILE, AN END-OF-FILE OR AN END-OF-INFORMATION WAS ENCOUNTERED.
- 1166 *** SYSTEM FATAL MESSAGE 1166, ON AN ATTEMPT TO READ A SEQUENTIAL FILE, A LONG RECORD WAS ENCOUNTERED.
- 1167 *** SYSTEM FATAL MESSAGE 1167, ON AN ATTEMPT TO READ A SEQUENTIAL FILE A SHORT RECORD WAS ENCOUNTERED.
- 1168 *** SYSTEM FATAL MESSAGE 1168, A CALL TO I06600 WITH 0PC0DE=5 (FORWARD SPACE) IS NOT SUPPORTED.
- 1169 *** SYSTEM FATAL MESSAGE 1169, ILLEGAL CALL TYPE, LOGIC ERROR IN I06600.
- 1170 *** SYSTEM FATAL MESSAGE 1170, ILLEGAL CALL TO NASTI0, LOGIC ERROR IN I06600.
- 1171 *** SYSTEM FATAL MESSAGE 1171, ON A POSITION CALL, THE BLOCK NUMBER REQUESTED IS NOT FOUND IN CORE WHEN IT IS EXPECTED THERE.
- Either the caller has written in the area furnished to NASTI0 or there is a logic error in NASTI0.
- 1172 *** SYSTEM FATAL MESSAGE 1172, WHEN ATTEMPTING TO READ A NEW INDEX, THE NUMBER OF WORDS RETURNED WAS INCORRECT.
- Either an I/O error or logic error in NASTI0.
- 1201 *** SYSTEM FATAL MESSAGE 1201, FIAT OVERFLOW.
- FIAT /XFIAT/ overflowed - reduce number of logical files. See Section 2.4 of the Programmer's Manual.
- 1202 *** SYSTEM FATAL MESSAGE 1202, DPL OVERFLOW.
- Data Pool Dictionary /XDPL/ overflowed - increase compiled size. See Section 2.4 of the Programmer's Manual.
- 1300 *** SYSTEM FATAL MESSAGE, END-OF-FILE WAS CALLED ON A FILE OPEN FOR INPUT.
- 1301 *** SYSTEM FATAL MESSAGE, END-OF-FILE ENCOUNTERED.
- An error in the calling program caused an unexpected end-of-file.
- 1302 *** SYSTEM FATAL MESSAGE, ZERO LENGTH RECORD SEGMENT ENCOUNTERED.
- A zero length record segment occurred before the last record in a block.
- 1303 *** SYSTEM FATAL MESSAGE, ATTEMPT TO GET A STRING PRIOR TO INFORMATION.
- There is an error in the calling program.
- 1304 *** SYSTEM FATAL MESSAGE, UNRECOGNIZED CONTROL WORD.
- The calling program may have overwritten a buffer.

NASTRAN SYSTEM AND USER MESSAGES

1305 *** SYSTEM FATAL MESSAGE, BLOCK NUMBER CHECK FAILED.

In the process of making a data block core resident, the block number did not have the expected value.

1306 *** SYSTEM FATAL MESSAGE, BLOCK NUMBER IN BLOCK TO BE WRITTEN DOES NOT MATCH NUMBER IN FILE CONTROL BLOCK.

1307 *** SYSTEM FATAL MESSAGE, BLOCK NUMBER OF BLOCK TO BE WRITTEN IS NOT IN CURRENT UNIT.

The block number was not in the current unit and not equal to the block number in the preceding unit.

1308 *** SYSTEM FATAL MESSAGE, ATTEMPT TO READ BEYOND DATA.

1309 *** SYSTEM FATAL MESSAGE, CORE RESIDENT DATA BLOCK NUMBER DOES NOT MATCH NUMBER IN FILE CONTROL BLOCK.

1310 *** SYSTEM FATAL MESSAGE, POINTER TO NEXT CORE RESIDENT DATA BLOCK IS ZERO

Next block should be in core.

1311 *** SYSTEM FATAL MESSAGE, BLOCK NUMBER TO BE READ IS NOT INCLUDED IN CURRENT CHAIN OF UNITS.

1312 *** SYSTEM FATAL MESSAGE, BLOCK NUMBER OF BLOCK READ FROM DISK DOES NOT MATCH NUMBER IN FILE CONTROL BLOCK.

1313 *** SYSTEM FATAL MESSAGE, POINTER TO CORE RESIDENT DATA BLOCK IS POSITIONED PRIOR TO INFORMATION.

1314 *** SYSTEM FATAL MESSAGE, ATTEMPT TO POSITION A FILE OPENED TO WRITE.

1315 *** SYSTEM FATAL MESSAGE, BLOCK NUMBER NOT FOUND.

Logic error in an attempt to position a core resident data block.

1316 *** SYSTEM FATAL MESSAGE, NO DATA EVENT CONTROL BLOCK AVAILABLE.

1317 *** SYSTEM FATAL MESSAGE, ERROR IN INTERNAL SUBROUTINE IN NASTI0.

1318 *** SYSTEM FATAL MESSAGE, ATTEMPT TO READ BEYOND END-OF-DATA.

NASTRAN SYSTEM AND USER MESSAGES

1319 *** SYSTEM FATAL MESSAGE, DCB SYNCHRONOUS ERROR DETECTED.

Data control block improperly written.

1320 *** SYSTEM FATAL MESSAGE, FIRST TERM IN ROW IS NOT A DIAGONAL TERM.

1321 *** SYSTEM FATAL MESSAGE, FIRST TERM IN ROW IS NOT A DIAGONAL TERM.

1322 *** SYSTEM FATAL MESSAGE 1322, BAD STATUS RETURN ON A NTRAN READ CALL.

Possible I/O error.

1323 *** SYSTEM FATAL MESSAGE 1323, END-OF-DATA ENCOUNTERED.

The unit on which the end-of-data occurred is not a tape.

1324 *** SYSTEM FATAL MESSAGE 1324, INCORRECT WORD COUNT ON A NTRAN READ CALL.

Number of words read by NTRAN is incorrect.

1325 *** SYSTEM FATAL MESSAGE 1325, BAD STATUS RETURN ON A NTRAN WRITE CALL.

Possible I/O error.

1326 *** SYSTEM FATAL MESSAGE 1326, INCORRECT NUMBER OF WORDS PASSED BY NTRAN.

1327 *** SYSTEM FATAL MESSAGE 1327, ILLEGAL RETURN FROM FWDREC.

1701 *** SYSTEM WARNING MESSAGE 1701, AVAILABLE CORE EXCEEDED BY ***** LINE IMAGE BLOCKS.

1702 *** SYSTEM INFORMATION MESSAGE 1702, UTILITY MODULE SEEMAT WILL ABANDON PROCESSING DATA BLOCK *****.

1703 *** USER WARNING MESSAGE 1703, PRECEDING BULK DATA DECK HAS BEEN CANCELED AND WILL NOT APPEAR ON USER MASTER FILE.

The preceding Bulk Data Deck contains errors which preclude its inclusion on the User Master File. Appropriate error messages should appear in the echo of the Bulk Data Deck. Any subsequent Bulk Data Decks will be placed on the User Master File if error-free.

1704*** USER FATAL MESSAGE 1704, ILLEGAL TID VALUE ON UMF CARD.

The TID value used on all UMF cards must be the same for any run and must match the TID value on the UMF tape being input. See Section 2.5 of the User's Manual for details.

1705 *** Reserved for future implementation in the User Master File Editor.

1706 *** Reserved for future implementation in the User Master File Editor.

DIAGNOSTIC MESSAGES

1707 *** SYSTEM FATAL MESSAGE 1707, UMFEDT - UNEXPECTED EOF FROM READ.

The occurrence of this message indicates a program failure in the User Master File Editor subroutine UMFEDT.

1708 *** SYSTEM FATAL MESSAGE 1708, UMFEDT - UNEXPECTED EOR FROM READ.

The occurrence of this message indicates a program failure in the User Master File Editor subroutine UMFEDT.

1709 *** SYSTEM FATAL MESSAGE 1709, UMFEDT UNABLE TO OPEN ONE OF THE PERMANENT NASTRAN FILES UMF, NUMF, OR NPTP.

1710 *** Reserved for future implementation in the User Master File Editor.

1711 *** USER FATAL MESSAGE 1711, NO TAPE SETUP FOR EITHER UMF OR NUMF. THE USER MASTER FILE EDITOR REQUIRES AT LEAST ONE OF THESE TAPES TO BE SET UP.

The tape(s) required must be appropriate to the requested action. See Section 2.5 of the User's Manual for details.

1712 *** Reserved for future implementation in the User Master File Editor.

1713 *** Reserved for future implementation in the User Master File Editor.

1714 *** Reserved for future implementation in the User Master File Editor.

1715 *** Reserved for future implementation in the User Master File Editor.

1716 *** Reserved for future implementation in the User Master File Editor.

1717 *** USER WARNING MESSAGE 1717, REQUEST TO ADD DECK WITH PROBLEM IDENTIFICATION NO. = ****
(1) CONFLICTS WITH IMPLIED REQUEST TO COPY THE SAME PROBLEM FROM THE UMF. THE NEW DECK WILL BE USED.

This message will occur whenever a deck is added whose PID value is the same as that of a problem already existing on the old User Master File.

1717 *** USER WARNING MESSAGE 1717, ILLEGAL PLOTTER SPECIFIED FOR SEEMAT (*****).
(2)

1718 *** USER WARNING MESSAGE 1718, REMOVE REQUEST FOR PROBLEM **** IS OUT OF SEQUENCE OR NOT ON UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1719 *** USER WARNING MESSAGE 1719, LIST REQUEST FOR PROBLEM **** IS OUT OF SEQUENCE OR NOT ON UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

NASTAN SYSTEM AND USER MESSAGES

- 1720 *** USER WARNING MESSAGE 1720, PUNCH REQUEST FOR PROBLEM **** IS OUT OF SEQUENCE OR NOT ON UMF.
(1)
User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.
- 1720 *** USER WARNING MESSAGE 1720, PLOT FILE - **** NOT SET UP.
(2)
- 1721 *** USER FATAL MESSAGE 1721, PROBLEM WITH PID = **** IS NOT ON UMF OR CARD IS OUT OF SEQUENCE.
User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.
- 1722 *** USER FATAL MESSAGE 1722, NUMF TAPE ID HAS ALREADY BEEN SPECIFIED.
The tape id value for the New User Master File (NUMF) may only be specified once. See Section 2.5 of the User's Manual for details.
- 1723 *** USER FATAL MESSAGE 1723, NUMF TAPE ID MAY NOT BE RESPECIFIED.
The tape id value for the New User Master File (NUMF) may only be specified once. See Section 2.5 of the User's Manual for details.
- 1724 *** USER WARNING MESSAGE 1724, PUNPRT REQUEST FOR PROBLEM **** IS OUT OF SEQUENCE OR NOT ON UMF.
(1)
User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.
- 1724 *** USER WARNING MESSAGE 1724, LOGIC ERROR AT STATEMENT ***** IN SUBROUTINE SEEMAT.
(2)
- 1725 *** Reserved for future implementation in the User Master File Editor.
- 1726 *** Reserved for future implementation in the User Master File Editor.
- 1727 *** Reserved for future implementation in the User Master File Editor.
- 1728 *** SYSTEM FATAL ERROR 1728, UMFEDT UNABLE TO LOCATE BULK DATA ON NPTP.
- 1729 *** Reserved for future implementation in the User Master File Editor.
- 1730 *** Reserved for future implementation in the User Master File Editor.
- 1731 *** Reserved for future implementation in the User Master File Editor.
- 1732 *** Reserved for future implementation in the User Master File Editor.
- 1733 *** Reserved for future implementation in the User Master File Editor.

DIAGNOSTIC MESSAGES

1734 *** Reserved for future implementation in the User Master File Editor.

1735 *** Reserved for future implementation in the User Master File Editor.

1736 *** USER FATAL ERROR 1736, BAD USER MASTER FILE EDITOR DATA CARD.

See Section 2.5 of the User's Manual for instructions for using the User Master File Editor.

1737 *** Reserved for future implementation in the User Master File Editor.

1738 *** USER FATAL MESSAGE 1738, UTILITY MODULE INPUT FIRST PARAMETER VALUE *** OUT OF RANGE.

In the test problem generating version of utility module INPUT, the first parameter value specifies the specific problem type as follows:

1. Laplace circuit (an $N \times N$ array of scalar points connected by scalar springs and optionally by scalar masses).
2. Rectangular frame made from BARS or RODs.
3. Rectangular plate made from QUAD1 elements.
4. Rectangular plate made from TRIA1 elements.
5. N-segment string modeled with scalar elements.
6. N-cell beam made from BAR elements.
7. N-order full matrix generator with optional load.
8. N-spoke bicycle wheel.

1739 *** SYSTEM FATAL MESSAGE 1739, UNABLE TO OPEN FILE ***.

This message can occur if a required output file is purged in utility module INPUT.

1740 *** SYSTEM FATAL MESSAGE 1740, EOF ENCOUNTERED.

An unexpected End-Of-File has been encountered while reading an input data block in utility module INPUT.

1741 *** SYSTEM FATAL MESSAGE 1741, EOR ENCOUNTERED.

An unexpected End-Of-Logical Record indicator has been encountered while reading an input data block in utility module INPUT.

1742 *** SYSTEM FATAL MESSAGE 1742, NO DATA PRESENT.

Utility module INPUT - input data block contains no data records.

1743 *** SYSTEM FATAL MESSAGE 1743, EOF FROM FWDREC.

Utility module INPUT encountered an End-Of-File on an input data block while attempting to read past the header record.

NASTRAN SYSTEM AND USER MESSAGES

1744 *** USER FATAL MESSAGE 1744, DATA CARD(S) ***** GENERATED BY UTILITY MODULE INPUT NOT ALLOWED IN BULK DATA.

Module is not capable of integrating same card type from two sources.

1745 *****

Message 1745 is reserved for utility module INPUT.

6.2.3 Functional Module Messages

2001 *** USER FATAL MESSAGE 2001, SEQGP CARD REFERENCES UNDEFINED GRID POINT ****.

2002 *** SYSTEM FATAL MESSAGE 2002, GRID POINT **** NOT IN EQEXIN.

This message indicates a program design error in GP1.

2003 *** USER FATAL MESSAGE 2003, COORDINATE SYSTEM **** REFERENCES UNDEFINED GRID POINT ****.

Applies to CORD1j definitions.

2004 *** USER FATAL MESSAGE 2004, COORDINATE SYSTEM **** REFERENCES UNDEFINED COORDINATE SYSTEM ****.

Applies to CORD2j definitions.

2005 *** SYSTEM FATAL MESSAGE 2005, INCONSISTENT COORDINATE SYSTEM DEFINITION.

At least one coordinate system cannot be tied to the basic system. See Section 4.21.7 of the Programmer's Manual.

2006 *** USER FATAL MESSAGE 2006, INTERNAL GRID POINT **** REFERENCES UNDEFINED COORDINATE SYSTEM ****.

The grid point whose internal sequence number is printed above references an undefined coordinate system in either field 3 or field 7 of a GRID card.

2007 *** USER FATAL MESSAGE 2007, ELEMENT **** REFERENCES UNDEFINED GRID POINT ****.

2008 *** USER FATAL MESSAGE 2008, LOAD SET **** REFERENCES UNDEFINED GRID POINT ****.

2009 *** USER FATAL MESSAGE 2009, TEMP SET **** REFERENCES UNDEFINED GRID POINT ****.

2010 *** USER FATAL MESSAGE 2010, ELEMENT **** REFERENCES UNDEFINED PROPERTY ****.

2011 *** USER FATAL MESSAGE 2011, NO PROPERTY CARD FOR ELEMENT TYPE ****.

2012 *** USER FATAL MESSAGE 2012, GRID POINT **** SAME AS SCALAR POINT.

Identification of grid and scalar points must be unique.

DIAGNOSTIC MESSAGES

2013 *** USER WARNING MESSAGE 2013, NO STRUCTURAL ELEMENTS EXIST.

Model checked for structural elements.

2014 *** SYSTEM FATAL MESSAGE 2014, LOGIC ERROR IN ECPT CONSTRUCTION.

The spill logic in the construction of the skeleton (TA1B) has failed. Problem should be referred to maintenance programming staff. A temporary fix may be available if additional storage can be provided to NASTRAN e.g., by increasing the region size (IBM 360).

2015 *** EITHER NO ELEMENTS CONNECT INTERNAL GRID POINT ***** OR IT IS CONNECTED TO A RIGID ELEMENT OR A GENERAL ELEMENT.

The message is a warning only since the degrees of freedom associated with the point may be removed by multipoint constraints or in other ways. The internal identification number is formed by assigning to each grid point and scalar point one of the integers 1,2, --- according to its resequenced position. It may be determined from data block EQEXIN via a DMAP TABPT instruction.

2016 *** USER INFORMATION MESSAGE 2016, GIVENS TIME ESTIMATE IS ***** SECONDS.
(1) PROBLEM SIZE IS ***** , SPILL WILL OCCUR FOR THIS
CORE AT A PROBLEM SIZE OF ***** .

2016 *** USER FATAL MESSAGE 2016, NO MATERIAL PROPERTIES EXIST.
(2)

2017 *** USER FATAL MESSAGE 2017, MATS1 CARD REFERENCES UNDEFINED MAT1 **** CARD.

The user should check that all MATS1 cards reference MAT1 cards that exist in the Bulk Data Deck.

2018 *** USER FATAL MESSAGE 2018, MATS2 CARD REFERENCES UNDEFINED MAT2 **** CARD.

The user should check that all MATS2 cards reference MAT2 cards that exist in the Bulk Data Deck.

2019 *** USER FATAL MESSAGE 2019, MATT1 CARD REFERENCES UNDEFINED MAT1 **** CARD.

The user should check that all MATT1 cards reference MAT1 cards that exist in the Bulk Data Deck.

2020 *** USER FATAL MESSAGE 2020, MATT2 CARD REFERENCES UNDEFINED MAT2 **** CARD.

The user should check that all MATT2 cards reference MAT2 cards that exist in the Bulk Data Deck.

NASTRAN SYSTEM AND USER MESSAGES

2021 *** SYSTEM FATAL MESSAGE 2021, BAD GMMAT CALLING SEQUENCE.

The calling sequence of the subroutine which call either subroutine GMMATD or GMMATS defined a nonconformable matrix product. The subroutine examines the transpose flags in combination with the orders of the matrices to make sure that a conformable matrix product is defined by this input data. This test clearly is made for purposes of calling routine checkout only. No tests are made, nor can they be made, to insure that the calling routine has provided sufficient storage for arrays.

2022 *** SYSTEM FATAL MESSAGE 2022, SMA-B SCALAR POINT INSERTION LOGIC ERROR.

Problem error in creating the ECPT data block in module TA1. Use the TABPT module to print ECPT.

2023 *** SYSTEM FATAL MESSAGE 2023, DETCK UNABLE TO FIND PIVOT POINT **** IN GPCT.

Probable error in creating the ECPT data block in module TA1. Use the TABPT module to print ECPT.

2024 *** USER FATAL MESSAGE 2024, OPERATION CODE ***** NOT DEFINED FOR MODULE PARAM.

The use of V,N,SUB rather than C,N,SUB can cause this.

NASTRAN SYSTEM AND USER MESSAGES

2025 *** USER FATAL MESSAGE 2025, UNDEFINED COORDINATE SYSTEM ****.

The coordinate system identification number transmitted via ECPT(1) could not be found in the CSTM array. The user should check coordinate system numbers used on bulk data cards against those defined on CORDIC, CORDIR, etc., bulk data cards to insure that there are no undefined coordinate systems.

2026 *** USER FATAL MESSAGE 2026, ELEMENT **** GEOMETRY YIELDS UNREASONABLE MATRIX.

Referenced element geometry and/or properties yields a numerical result which causes an element stiffness or mass matrix to be undefined. Possible causes include, but are not limited to, (1) the length of a rod or bar is zero because the end points have the same coordinates, (2) the sides of a triangle or quadrilateral are collinear which leads to a zero cross product in defining an element coordinate system, or (3) the bar orientation vector is parallel to the bar axis. Check GRID bulk data cards defining element end points for bad data.

2027 *** USER FATAL MESSAGE 2027, ELEMENT **** HAS INTERIOR ANGLE GREATER THAN 180 DEG. AT GRID POINT ****.

SHEAR or TWIST panel element with the referenced element number has been defined with the four grid points out of the proper cyclical order. See bulk data card definitions for CSHEAR and CTWIST cards.

2028 *** SYSTEM FATAL MESSAGE 2028, SMA3A ERROR NO. ****.

Internal logic error in subroutine SMA3A of module SMA3. Possible error in generation of the GEI data block. Use the TABPT module to print GEI.

2029 *** USER FATAL MESSAGE 2029, UNDEFINED TEMPERATURE SET ****.

The referenced temperature set had no default temperature defined. Define a temperature or default temperature for each grid point in the model.

2030 *** SYSTEM FATAL MESSAGE 2030, BAD GPTT.

The format of the GPTT data block is incorrect. Use the TABPT module to print the GPTT data block.

2031 *** USER FATAL MESSAGE 2031, ELEMENT **** UNACCEPTABLE GEOMETRY.

2032 *** USER FATAL MESSAGE 2032, ELEMENT **** UNACCEPTABLE GEOMETRY.

2033 *** USER FATAL MESSAGE 2033, SINGULAR H-MATRIX FOR ELEMENT ****.

2034 *** SYSTEM FATAL MESSAGE 2034, ELEMENT **** SIL'S DO NOT MATCH PIVOT.

Possible error in generation of the ECPT data block. Use the TABPT module to print ECPT.

2035 *** USER FATAL MESSAGE 2035, QUADRILATERAL **** INTERIOR ANGLE GREATER THAN 180 DEG.

2036 *** USER FATAL MESSAGE 2036, SINGULAR MATRIX FOR ELEMENT ****.

2037 *** USER FATAL MESSAGE 2037, BAD ELEMENT **** GEOMETRY.

DIAGNOSTIC MESSAGES

2038 *** SYSTEM FATAL MESSAGE 2038, SINGULAR MATRIX FOR ELEMENT ****.

2039 *** USER FATAL MESSAGE 2039, ZERO SLANT LENGTH FOR HARMONIC **** OF CCONEAX ****.

2040 *** USER FATAL MESSAGE 2040, SINGULAR MATRIX FOR ELEMENT ****.

2041 *** USER FATAL MESSAGE 2041, A MATT1,MATT2,MATT3 OR MATS1 CARD REFERENCES TABLE NUMBER **** WHICH IS NOT DEFINED ON A TABLE1, TABLE2, TABLE3, TABLE4 OR TABLES1 CARD.

The user must insure that all table identification numbers on MATT1, MATT2, MATT3, or MATS1 cards reference tables which exist in the Bulk Data Deck.

2042 *** USER FATAL MESSAGE 2042, MISSING MATERIAL TABLE **** FOR ELEMENT ****.

The referenced material table identification number is missing. The user should check to see that all element property bulk data cards (e.g., PBAR, PRPD) reference material card identification numbers for material property cards that exist in the Bulk Data Deck.

2043 *** USER WARNING MESSAGE 2043, OFP HAS INSUFFICIENT CORE FOR ONE GINØ BUFFER ****
(1) OFP NOT EXECUTED.

2043 *** USER FATAL MESSAGE 2043, MISSING MATERIAL TABLE *****.
(2)

2044 *** USER FATAL MESSAGE 2044, UNDEFINED TEMPERATURE SET ****.

The referenced temperature set was selected in the Case Control Deck but not defined in the Bulk Data Deck.

2045 *** USER FATAL MESSAGE 2045, TEMPERATURE UNDEFINED AT GRID POINT WITH INTERNAL INDEX ****.

Temperatures must be defined at all grid points in a selected temperature set. The grid point whose internal index was printed had no temperature defined and a default temperature was not supplied for the selected temperature set.

2046 *** USER FATAL MESSAGE 2046, UNDEFINED ELEMENT DEFORMATION SET ****.

2047 *** USER FATAL MESSAGE 2047, UNDEFINED MULTIPØINT CØNSTRAINT SET ****.

A multipoint constraint set selected in the Case Control Deck could not be found in either an MPC or MPCADD card or a set referenced on a MPCADD card could not be found on an MPC card.

2048 *** USER FATAL MESSAGE 2048, UNDEFINED GRID POINT **** IN MULTI-POINT CØNSTRAINT SET ****.

2049 *** USER FATAL MESSAGE 2049, UNDEFINED GRID POINT **** HAS AN ØMITTED CØØRDINATE.

An ØMIT or ØMIT1 card references a grid point which has not been defined.

NASTRAN SYSTEM AND USER MESSAGES

- 2050 *** USER FATAL MESSAGE 2050, UNDEFINED GRID POINT **** HAS A SUPPORT COORDINATE.
A SUPORT card references a grid point which has not been defined.
- 2051 *** USER FATAL MESSAGE 2051, UNDEFINED GRID POINT **** IN SINGLE POINT CONSTRAINT SET ****.
An SPC1 card in the selected SPC set references a grid point which has not been defined.
- 2052 *** USER FATAL MESSAGE 2052, UNDEFINED GRID POINT *** IN SINGLE-POINT CONSTRAINT SET ****.
An SPC card in the selected SPC set references a grid point which has not been defined.
- 2053 *** USER FATAL MESSAGE 2053, UNDEFINED SINGLE-POINT CONSTRAINT SET ****.
A single point constraint set selected in the Case Control Deck could not be found on either an SPCADD, SPC or SPC1 card, or a set referenced on an SPCADD card could not be found on either an SPC or SPC1 card.
- 2054 *** USER FATAL MESSAGE 2054, SUPER ELEMENT **** REFERENCES UNDEFINED SIMPLE ELEMENT ****.
- 2055 *** SYSTEM WARNING MESSAGE 2055, NODD FLAG IS ON AT ENTRY TO SMAIA AND IS BEING TURNED OFF.
- 2056 *** USER FATAL MESSAGE 2056, UNDEFINED SUPER ELEMENT **** PROPERTIES.
- 2057 *** USER FATAL MESSAGE 2057, IRRATIONAL SUPER ELEMENT **** TOPLOGY.
- 2058 *** USER WARNING MESSAGE 2058, ELEMENT ***** CONTRIBUTES TO THE DAMPING MATRIX WHICH IS PURGED. IT WILL BE IGNORED.
- 2059 *** USER FATAL MESSAGE 2059, UNDEFINED GRID POINT **** ON SE--BFE FOR SUPER ELEMENT ****.
- 2060 *** USER FATAL MESSAGE 2060, UNDEFINED GRID POINT **** ON QDSEP CARD FOR SUPER ELEMENT ****.
- 2061 *** USER FATAL MESSAGE 2061, UNDEFINED GRID POINT **** ON GENERAL ELEMENT ****.
- 2062 *** USER FATAL MESSAGE 6062, UNDEFINED SUPER ELEMENT PROPERTY **** FOR SUPER ELEMENT ****.
- 2063 *** SYSTEM FATAL MESSAGE 2063, TAIC LOGIC ERROR. GENERAL ELEMENT DATA COULD NOT BE FOUND IN THE ECT DATA BLOCK WHEN TRAILER LIST INDICATED IT WAS PRESENT. REFER PROBLEM TO MAINTENANCE PROGRAMMING STAFF.
- 2064 *** USER FATAL MESSAGE 2064, UNDEFINED EXTRA POINT **** REFERENCED ON SEQEP CARD.
- 2065 *** USER FATAL MESSAGE 2065, UNDEFINED GRID POINT **** ON DMIG CARD.
- 2066 *** USER FATAL MESSAGE 2066, UNDEFINED GRID POINT **** ON RLQAD- OR TLQAD- CARD.
- 2067 *** USER FATAL MESSAGE 2067, UNDEFINED GRID POINT **** ON NOLIN- CARD.

DIAGNOSTIC MESSAGES

2068 *** USER FATAL MESSAGE 2068, UNDEFINED GRID POINT **** IN TRANSFER FUNCTION SET ****.

2069 *** USER FATAL MESSAGE 2069, UNDEFINED GRID POINT **** IN TRANSIENT INITIAL CONDITION SET ****.

2070 *** USER FATAL MESSAGE 2070, REQUESTED DMIG MATRIX **** IS UNDEFINED.

2071 *** USER FATAL MESSAGE 2071, DYNAMIC LOAD SET **** REFERENCES UNDEFINED TABLE ****.

2072 *** SYSTEM WARNING MESSAGE 2072, CARD TYPE *** NOT FOUND ON DATA BLOCK.

This warning message is issued when the trailer bit for the card type = 1 but the corresponding record is not on the data block.

NASTRAN SYSTEM AND USER MESSAGES

2073 *** USER INFORMATION MESSAGE 2073, MPYAD METHOD = ****, NO. OF PASSES = ****.

This message gives the method selected and number of passes required.

2074 *** USER FATAL MESSAGE 2074, UNDEFINED TRANSFER FUNCTION SET ****.

2075 *** SYSTEM OR USER DMAP FATAL MESSAGE 2075, IMPROPER VALUE **** FOR FIRST PARAMETER IN DMAP INSTRUCTION SDR2.

2076 *** USER WARNING MESSAGE 2076, SDR2 OUTPUT DATA BLOCK NO. 1 IS PURGED.

2077 *** USER WARNING MESSAGE 2077, SDR2 OUTPUT DATA BLOCK NO. 2 IS PURGED.

2078 *** USER WARNING MESSAGE 2078, SDR2 OUTPUT DATA BLOCK NO. 3 IS PURGED.

2079 *** USER WARNING MESSAGE 2079, SDR2 FINDS THE -EDT-, -EST-, OR -GPTT- PURGED OR INADEQUATE AND IS THUS NOT PROCESSING ANY REQUESTS FOR STRESSES OR FORCES.

2080 *** USER WARNING MESSAGE 2080, SDR2 OUTPUT DATA BLOCK NO. 6 IS PURGED.

2081 *** USER FATAL MESSAGE 2081, NULL DIFFERENTIAL STIFFNESS MATRIX.

Differential stiffness is not defined for all structural elements. Only the following elements are defined for differential stiffness calculations: ROD, TUBE, SHEAR (but not TWIST) panels, triangular and quadrilateral membranes (TRMEM, TRIA2, QDMEM, QUAD2), and BAR. The combination two dimensional elements TRIA1 and QUAD1, are defined only if their membrane thickness is nonzero. The user has not included any of these elements in his model and therefore a null differential stiffness matrix was generated.

2083 *** USER FATAL MESSAGE 2083, NULL DISPLACEMENT VECTOR.

The displacement vector for the linear solution part of a static analysis with differential stiffness problem, or the incremental displacement vector in a piecewise linear analysis rigid format problem is the zero vector. Check loading conditions.

2084 *** SYSTEM FATAL MESSAGE 2084, DSMG2 LOGIC ERROR ****.

Incompatible input and output pairs in the DMAP calling sequence to module DSMG2. See the module description for DSMG2 in the Programmer's Manual.

2085 *** USER INFORMATION MESSAGE 2085, **** SPILL, NPVT ****.

During processing of the ECPT data block in module ****, so many elements were attached to the referenced pivot point (NPVT) that module spill logic was initiated.

2086 *** USER INFORMATION MESSAGE 2086, SMA2 SPILL, NPVT ****.

See explanation for Message 2085.

2087 *** SYSTEM FATAL MESSAGE 2087, ECPT CONTAINS BAD DATA.

Use the TABPT module to print the ECPT data block.

DIAGNOSTIC MESSAGES

- 2088 *** USER FATAL MESSAGE 2088, DUPLICATE TABLE ID ****.
All tables must have unique numbers. Check for uniqueness.
- 2089 *** USER FATAL MESSAGE 2089, TABLE **** UNDEFINED.
The table number in the list of table numbers input to subroutine PRETAB via argument 7 was not found after reading the DIT data block. Check list of tables in the Bulk Data Deck.
- 2090 *** SYSTEM FATAL MESSAGE 2090, TABLE DICTIONARY ENTRY **** MISSING.
Logic error in subroutine PRETAB, or open core used by PRETAB has been destroyed.
- 2091 *** SYSTEM FATAL MESSAGE 2091, PLA3, BAD ESTNL EL ID ****.
ESTNL data block is not in expected format. Use TABPT module to print the ESTNL data block.
- 2092 *** SYSTEM WARNING MESSAGE 2092, SDR2 FINDS A SYMMETRY SEQUENCE LENGTH = **** AND AN INSUFFICIENT NUMBER OF VECTORS AVAILABLE = **** WHILE ATTEMPTING TO COMPUTE STRESSES AND FORCES. ALL FURTHER STRESS AND FORCES COMPUTATION TERMINATED.
- 2093 *** USER FATAL MESSAGE 2093, NOLIN CARD FROM NOLIN SET **** REFERENCES GRID POINT **** UD SET.
- 2094 *** USER WARNING MESSAGE 2094, SUBROUTINE TABFMT, KEYNAME ***** NOT IN LIST OF AVAILABLE KEYNAMES. *** LIST OF RECOGNIZED KEYNAMES FOLLOWS.

The TABPRT Module can only be used to print certain table data blocks. For table data blocks not appearing in the list, use the TABPT Module.
- 2095 *** USER WARNING MESSAGE 2095, SUBROUTINE TABFMT, PURGED INPUT.
- 2096 *** USER WARNING MESSAGE 2096, SUBROUTINE TABFMT, EOF ENCOUNTERED.
- 2097 *** USER WARNING MESSAGE 2097, SUBROUTINE TABFMT, EOR ENCOUNTERED.
- 2098 *** USER WARNING MESSAGE 2098, SUBROUTINE TABFMT, INSUFFICIENT CORE.
- 2099 *** USER WARNING MESSAGE 2099, SUBROUTINE TABFMT, KF *****.
- 2101A *** USER FATAL MESSAGE 2101A, GRID POINT **** COMPONENT *** ILLEGALLY DEFINED IN SETS ****.
The above grid point and component has been defined in each of the above dependent subsets. A point may belong to at most one dependent subset.
- 2101B *** USER FATAL MESSAGE 2101B, SCALAR POINT **** ILLEGALLY DEFINED IN SETS ****.
- 2102 *** USER WARNING MESSAGE 2102, LEFT-HAND MATRIX ROW POSITION **** OUT OF RANGE - IGNORED.
A term in the A matrix whose row position is larger than the stated dimension was detected and ignored.

NASTRAN SYSTEM AND USER MESSAGES

- 2103 *** SYSTEM FATAL MESSAGE 2103, SUBROUTINE MAT WAS CALLED WITH INFLAG=2, THE SINE OF ANGLE X, MATERIAL ORIENTATION ANGLE, NONZERO, BUT $\sin(X)^2 + \cos(X)^2$ DIFFERED FROM 1 IN ABSOLUTE VALUE BY MORE THAN .0001.
A check is made in MAT to insure that $ABS(\sin(\theta)^2 + \cos(\theta)^2 - 1.00) \leq .0001$ when INFLAG = 2. The calling routine did not set SINTH and COSTH cells in /MATIN/ properly.
- 2104 *** USER FATAL MESSAGE 2104, UNDEFINED COORDINATE SYSTEM ****.
See the explanation for Message 2025.
- 2105 *** USER FATAL MESSAGE 2105, PL0AD2 CARD FROM LOAD SET **** REFERENCES MISSING OR NON-2-D ELEMENT ****.
PL0AD2 cards must reference two-dimensional elements.
- 2106 *** USER FATAL MESSAGE 2106, LOAD CARD DEFINES NONUNIQUE LOAD SET ****.
- 2107 *** USER FATAL MESSAGE 2107, EIG-CARD FROM SET **** REFERENCES DEPENDENT COORDINATE OR GRID POINT ****.
When the point option is used on an EIGB, EIGC or EIGR card, the referenced point and component must be in the analysis set for use in normalization.
- 2108 *** USER FATAL MESSAGE 2108, NO XY-PL0TTER HAS BEEN SPECIFIED TO THIS POINT.
- 2109 *** USER FATAL MESSAGE 2109, NO GRID, SCALAR OR EXTRA POINTS DEFINED.
- 2110 *** USER WARNING MESSAGE 2110, INSUFFICIENT CORE TO HOLD CONTENTS OF GIN0 FILE *** FURTHER PROCESSING OF THIS DATA BLOCK IS ABANDONED.

DIAGNOSTIC MESSAGES

2111 *** USER WARNING MESSAGE 2111, BAR **** COUPLED BENDING INERTIA SET TO 0.0 IN DIFFERENTIAL STIFFNESS.

The coupled bending inertia term on a PBAR card, if nonzero, is set to zero in the differential stiffness routine for the BAR.

2112 *** SYSTEM FATAL MESSAGE 2112, UNDEFINED TABLE ****.

The referenced table number could not be found in core.

2113 *** USER FATAL MESSAGE 2113, MATERIAL ****, A NON-MAT1 TYPE, IS NOT ALLOWED TO BE STRESS DEPENDENT.

Only MAT1 material cards may be present in a piecewise linear analysis problem.

2114 *** USER FATAL MESSAGE 2114, MAT3 CARD REFERENCES UNDEFINED MAT3 **** CARD.

The user should check that all MAT3 cards reference MAT3 cards that exist in the Bulk Data Deck. This can also happen if ID noted by **** could not be found on MAT1 card (see Message 2042).

2115 *** USER FATAL MESSAGE 2115, TABLE **** (TYPE ****) ILLEGAL WITH STRESS-DEPENDENT MATERIAL.

Only TABLES1 cards may be used to define stress-strain curves for use in piecewise linear analysis.

2116 *** SYSTEM FATAL MESSAGE 2116, MATID **** TABLEID ****.

The referenced material table identification number could not be found among the set of all MAT1 cards in core.

2117 *** USER FATAL MESSAGE 2117, TEMPERATURE DEPENDENT MATERIAL PROPERTIES ARE NOT PERMISSIBLE IN A PIECEWISE LINEAR ANALYSIS PROBLEM. TEMPERATURE SET = ****.

User should redefine his problem without temperature dependent material properties.

2118 *** USER INFORMATION MESSAGE 2118, SUBROUTINE GP4PRT, - DIAG 21 SET-DOF VS. DISP SETS FOLLOWS.

2119 *** USER INFORMATION MESSAGE 2119, SUBROUTINE GP4PRT, - DIAG 22 SET-DISP SETS VS. DOF FOLLOWS.

2120 *** USER FATAL MESSAGE 2120, MODULE VEC - BOTH SUBSET BITS ARE NON-ZERO. I *****.

2121 *** USER FATAL MESSAGE 2121, MODULE VEC - BOTH SUBSET BITS ARE ZERO. I *****.

2122 *** USER FATAL MESSAGE 2122, MODULE VEC - SET X BIT IS ZERO BUT SUBSET X0 BIT IS NOT.
I *****.

2123 *** USER FATAL MESSAGE 2123, MODULE VEC - SET X BIT IS ZERO BUT SUBSET X1 BIT IS NOT.
I *****.

NASTRAN SYSTEM AND USER MESSAGES

2124 *** USER WARNING MESSAGE 2124, MODULE VEC - NR=0, OUTPUT WILL BE PURGED.

2125 *** USER WARNING MESSAGE 2125, MODULE VEC - NZ=0, OUTPUT WILL BE PURGED.

2126 *** USER FATAL MESSAGE 2126, MODULE VEC UNABLE TO OPEN GINØ FILE **** DATA BLOCK *****.
(1)

2126 *** USER FATAL MESSAGE 2126, UNDEFINED MATERIAL FOR ELEMENT *****.
(2)

2127 *** SYSTEM FATAL MESSAGE 2127, PLA2 INPUT DATA BLOCK NØ. **** IS PURGED.

Data blocks DELTAUGV and DELTAPG cannot be purged. See module description for PLA2 in Section 4 of the Programmer's Manual.

2128 *** SYSTEM FATAL MESSAGE 2128, PLA2 OUTPUT DATA BLOCK NØ. **** IS PURGED.

Data blocks UGV1, PGV1 cannot be purged. See module description for PLA2 in Section 4 of the Programmer's Manual.

2129 *** SYSTEM FATAL MESSAGE 2129, PLA2, ZERO VECTOR ON APPENDED DATA BLOCK NØ. ****.

Zero displacement vector found on UGV1 data block output from PLA2. Possible system failure.

NASTRAN SYSTEM AND USER MESSAGES

2130 *** USER FATAL MESSAGE 2130, ZERO INCREMENTAL DISPLACEMENT VECTOR NOT ADMISSIBLE AS INPUT TO MODULE PLA2.

See discussion of the Piecewise Linear Analysis rigid format.

2131 *** USER FATAL MESSAGE 2131, NON-SCALAR ELEMENT *** REFERENCES A SCALAR POINT.

An element which must be attached to a geometric grid point has been attached to a scalar point. No geometry data can be inferred.

2132 *** USER FATAL MESSAGE 2132, NON-ZERO SINGLE POINT CONSTRAINT VALUE SPECIFIED BUT DATA BLOCKS IS PURGED.

Many rigid formats do not support constrained displacements (especially dynamic solutions). An attempt to specify a constrained displacement in these cases results in this message.

2133 *** USER FATAL MESSAGE 2133, INITIAL CONDITION IN SET **** SPECIFIED FOR POINT NOT IN ANALYSIS SET.

Initial conditions can only be specified for analysis set points. Therefore the point/component mentioned on TIC cards must belong to the D or H sets.

2134 *** USER FATAL MESSAGE 2134, LOAD SET *** DEFINED FOR BOTH GRAVITY AND NON-GRAVITY LOADS.

The same load set identification number cannot appear on both a GRAV card and another loading card such as FORCE or MOMENT. To apply both a gravity load and a concentrated load simultaneously the LOAD card must be used.

2135 *** USER FATAL MESSAGE 2135, DLOAD CARD *** HAS A DUPLICATE SET ID FOR SET ID ***.

The Li set ID's on a DLOAD card are not unique. See DLOAD card description in the User's Manual.

2136 *** USER FATAL MESSAGE 2136, SET ID *** HAS BEEN DUPLICATED ON A DLOAD, RLAD1,2 or TLAD1,2 CARD.

All dynamic load set ID's must be unique.

2137 *** USER FATAL MESSAGE 2137, PROGRAM RESTRICTION FOR MODULE SSG1 - ONLY 100 LOAD SET ID'S ALLOWED. DATA CONTAINS **** LOAD SET ID'S.

Reduce the number of Load Set ID's.

2138 *** USER FATAL MESSAGE 2138, ELEMENT IDENTIFICATION NUMBER **** IS TOO LARGE.

Element identification numbers (on connection cards) must be less than 16,777,215.

2139 *** USER FATAL MESSAGE 2139, ELEMENT **** IN DEFORM SET **** IS UNDEFINED.

A selected element deformation set includes an element twice, includes a non-existent element, or includes a non-one-dimensional element.

DIAGNOSTIC MESSAGES

- 2140 *** USER FATAL MESSAGE 2140, GRID POINT OR SCALAR POINT ID *** IS TOO LARGE.
Program restriction on the size of integer numbers. A card defining a grid point or scalar point has a number larger than 2,000,000.
- 2141 *** USER FATAL MESSAGE 2141, MODULE VEC - EOF ENCOUNTERED WHILE READING GINØ FILE **** DATA BLOCK *****.
- 2142 *** USER FATAL MESSAGE 2142, INSUFFICIENT CORE FOR MODULE VEC. AVAILABLE CORE = ***** WORDS. ADDITIONAL CORE NEEDED = ***** WORDS.
- 2143 *** USER FATAL MESSAGE 2143, MODULE VEC UNABLE TO IDENTIFY SET OR SUBSET DESCRIPTION *****.
- 2144 *** USER FATAL MESSAGE 2144, MODULE VEC - EOF ENCOUNTERED DURING FWDREC OF GINØ FILE **** DATA BLOCK *****.
- 2145 *** USER FATAL MESSAGE 2145, ***** FATAL MESSAGES HAVE BEEN GENERATED IN SUBROUTINE VEC. ONLY THE FIRST **** HAVE BEEN PRINTED.
- 2146 *** USER FATAL MESSAGE 2146, BOTH OF THE SECOND AND THIRD VEC PARAMETERS REQUEST COMPLEMENT.
- 2147 *** SYSTEM FATAL MESSAGE 2147, ILLEGAL ELEMENT TYPE = ***** ENCOUNTERED BY DSMG MODULE.
- 2150 *** USER FATAL MESSAGE 2150, ILLEGAL VALUE FOR FOURTH PARAMETER = *****.
- 2151 *** USER WARNING MESSAGE 2151, -PLAARY- ARRAY IS SMALLER THAN MAXIMUM NUMBER OF ELEMENT TYPES.
- 2152 *** USER FATAL MESSAGE 2152, GRID POINT ***** COMPONENT ** DUPLICATELY DEFINED IN THE **** SET.
- 2153 *** USER FATAL MESSAGE 2153, SCALAR POINT ***** DUPLICATELY DEFINED IN THE **** SET.
- 2154 *** USER WARNING MESSAGE 2154, ZERO AREA OR ILLEGAL CONNECTION FOR HBDY ELEMENT NUMBER *****.
- 2155 *** USER WARNING MESSAGE 2155, MAT4 AND MAT5 MATERIAL DATA CARDS HAVE SAME ID = ***** MAT4 DATA WILL BE SUPPLIED WHEN CALLED FOR THIS ID.
- 2156 *** SYSTEM FATAL MESSAGE 2156, ILLEGAL INFLAG = ***** RECEIVED BY HMAT.
- 2157 *** USER FATAL MESSAGE 2157, MATERIAL ID = ***** DOES NOT APPEAR ON ANY MAT4 OR MAT5 MATERIAL DATA CARD.
- 2158 *** SYSTEM WARNING MESSAGE 2158, A TRAPRG ELEMENT = ***** DOES NOT HAVE SIDE 1-2 PARALLEL TO SIDE 3-4.
- 2159 *** USER FATAL MESSAGE 2159, TRIRG OR TRAPRG ELEMENT = ***** POSSESSES ILLEGAL GEOMETRY.

NASTRAN SYSTEM AND USER MESSAGES

- 2160 *** USER FATAL MESSAGE 2160, BAD GEOMETRY OR ZERO COEFFICIENT FOR SLOT ELEMENT NUMBER
*****.
- 2161 *** SYSTEM WARNING MESSAGE 2161, PARTITION FILE, **** IS OF SIZE ***** ROWS BY *****
COLUMNS. PARTITIONING VECTORS INDICATE THAT THIS PARTITION SHOULD BE OF SIZE *****
ROWS BY ***** COLUMNS FOR A SUCCESSFUL MERGE.
- 2162 *** SYSTEM WARNING MESSAGE 2162, THE FORM PARAMETER AS GIVEN TO THE MERGE MODULE IS
INCONSISTENT WITH THE SIZE OF THE MERGED MATRIX, HOWEVER IT HAS BEEN USED. FORM =
*****, SIZE = ***** ROWS BY ***** COLUMNS.
- 2163 *** SYSTEM WARNING MESSAGE 2163, THE FORM PARAMETER AS GIVEN TO THE MERGE MODULE HAS NOT BEEN
SET, OR IS OF ILLEGAL VALUE. THE FORM OF THE MERGED MATRIX HAS BEEN SET = *****.
- 2164 *** SYSTEM WARNING MESSAGE 2164, THE TYPE PARAMETER AS GIVEN TO THE MERGE MODULE HAS NOT BEEN
SET OR IS OF ILLEGAL VALUE. THE TYPE OF THE MERGED MATRIX HAS BEEN SET TO REAL-SINGLE-
PRECISION.
- 2165 *** USER FATAL MESSAGE 2165, ILLEGAL GEOMETRY OR ZERO COEFFICIENT FOR SLOT ELEMENT NUMBER
*****.
- 2166 *** SYSTEM WARNING MESSAGE 2166, MATRIX TO BE PARTITIONED IS OF SIZE ***** ROWS BY
***** COLUMNS. ROW PARTITION SIZE IS ***** COLUMN PARTITION SIZE IS *****
(INCOMPATIBLE).
- 2167 *** SYSTEM WARNING MESSAGE 2167, THE TYPE PARAMETER AS GIVEN TO THE PARTITIONING MODULE HAS
NOT BEEN SET OR IS OF ILLEGAL VALUE. THE TYPE OF THE PARTITIONS HAS BEEN SET TO REAL-
SINGLE-PRECISION.
- 2168 *** SYSTEM WARNING MESSAGE 2168, THE FORM PARAMETER AS GIVEN TO THE PARTITIONING MODULE FOR
SUB-PARTITION ***** IS INCONSISTENT WITH ITS SIZE. FORM = *****, SIZE =
***** ROWS BY ***** COLUMNS.
- 2169 *** SYSTEM WARNING MESSAGE 2169, THE FORM PARAMETERS AS GIVEN TO THE PARTITIONING MODULE FOR
SUB-PARTITION ***** HAS NOT BEEN SET OR IS OF ILLEGAL VALUE. IT HAS BEEN RESET =
*****.
- 2170 *** SYSTEM FATAL MESSAGE 2170, BOTH THE ROW AND COLUMN PARTITIONING VECTORS ARE PURGED AND
ONLY ONE MAY BE.
- 2171 *** SYSTEM WARNING MESSAGE 2171, SYM FLAG INDICATES TO THE PARTITION OR MERGE MODULE THAT A
SYMMETRIC MATRIX IS TO BE OUTPUT. THE PARTITIONING VECTORS ***** HOWEVER DO NOT
CONTAIN AN IDENTICAL NUMBER OF ZEROS AND NON-ZEROS.
- 2172 *** SYSTEM WARNING MESSAGE 2172, ROW AND COLUMN PARTITIONING VECTORS DO NOT HAVE IDENTICAL
ORDERING OF ZERO AND NON-ZERO ELEMENTS, AND SYM FLAG INDICATES THAT A SYMMETRIC
PARTITION OR MERGE IS TO BE PERFORMED.
- 2173 *** SYSTEM WARNING MESSAGE 2173, PARTITIONING VECTOR FILE **** CONTAINS ***** COLUMNS.
ONLY THE FIRST COLUMN IS BEING USED.

DIAGNOSTIC MESSAGES

- 2174 *** SYSTEM WARNING MESSAGE 2174, PARTITIONING VECTOR ON FILE **** IS NOT REAL-SINGLE OR REAL-DOUBLE PRECISION.
- 2175 *** SYSTEM FATAL MESSAGE 2175, THE ROW POSITION OF AN ELEMENT OF A COLUMN ON FILE **** IS GREATER THAN NUMBER OF ROWS SPECIFIED BY TRAILER.
- 2176 *** SYSTEM FATAL MESSAGE 2176, FILE **** EXISTS BUT IS EMPTY.
- 2177 *** USER INFORMATION MESSAGE 2177, SPILL WILL OCCUR IN SYMMETRIC COMPLEX DECOMPOSITION.
- 2178 *** SYSTEM FATAL MESSAGE 2178, GINØ REFERENCE NAMES, IMPROPER FOR SUBROUTINE FILSWI.
- 2179 *** SYSTEM FATAL MESSAGE 2179, ERROR DETECTED IN FUNCTION FORFIL ****, **** NOT IN FIST.
- 2180 *** USER WARNING MESSAGE 2180, SYMMETRIC DECOMPOSITION OF A MATRIX WHOSE FORM IS SQUARE (BUT NOT SYMMETRIC) WILL BE ATTEMPTED.
- 2181 *** SYSTEM FATAL MESSAGE 2181, SCDCMP CALLED TO SOLVE A 1X1 OR 2X2 MATRIX.
- 2182 *** USER WARNING MESSAGE 2182, SUBROUTINE ***** IS DUMMY. ONLY ONE OF THESE MESSAGES WILL APPEAR PER OVERLAY OF THIS DECK.
- 2183 *** USER WARNING MESSAGE 2183, SYMMETRIC DECOMPOSITION OF A MATRIX WHOSE FORM IS SQUARE (BUT NOT SYMMETRIC) WILL BE ATTEMPTED.
- 2184 *** SYSTEM WARNING MESSAGE 2184, STRESS OR FORCE REQUESTS FOR ELEMENT TYPE = ***** WILL NOT BE HONORED AS THIS ELEMENT IS UNDEFINED TO SDR2.
- Stress and force requests for fluid, mass, damping, plotel, and heat boundary elements are automatically ignored.
- 2187 *** USER FATAL MESSAGE 2187, INSUFFICIENT WORKING CORE TO HOLD FORTRAN LOGICAL RECORD. LENGTH OF WORKING CORE = *****.
LENGTH OF FORTRAN LOGICAL RECORD = *****.
- 2188 *** USER INFORMATION MESSAGE 2188, UNUSED CORE = ***** WORDS.
- 2189 *** USER INFORMATION MESSAGE 2189, ADDITIONAL CORE REQUIRED TO AVOID SPILL = ***** (DECIMAL) WORKS.
- 2190 *** SYSTEM FATAL MESSAGE 2190, ILLEGAL VALUE FOR KEY = *****. EXPECTED VALUE = *****.
- 2191 *** USER WARNING MESSAGE 2191, ELEMENT TYPE ***** IS PRESENT AND IS BEING IGNORED BY SMAI SINCE OPTION PARAM = *****.
- 2192 *** USER FATAL MESSAGE 2192. UNDEFINED GRID POINT, *****, IN RIGID ELEMENT, *****.

NASTRAN SYSTEM AND USER MESSAGES

- 2193 *** USER FATAL MESSAGE 2193, A REDUNDANT SET OF RIGID BODY MODES WAS SPECIFIED FOR THE GENERAL ELEMENT.
- Only a non-redundant list of rigid body modes is allowed to appear in the u_d set when the S matrix is to be internally calculated in subroutine TAICA.
- 2194 *** USER FATAL MESSAGE 2194, A MATRIX D IS SINGULAR IN SUBROUTINE TAICA.
- While attempting to calculate the [S] matrix for a general element in TAICA, it was discovered that the matrix D_d which relates $\{u_b\}$ to $\{u_d\}$ was singular and could not be inverted.
- 2195 *** USER WARNING MESSAGE 2195, ILLEGAL VALUE FOR P4 = *****.
- 2196 *** USER WARNING MESSAGE 2196, DUMMY SUBROUTINE TIMTS3.
DUMMY SUBROUTINE TIMTS4.
DUMMY SUBROUTINE TIMTS5.
- 2197 *** SYSTEM FATAL MESSAGE 2197, ABORT CALLED DURING TIME TEST OF *****.
- 2198 *** SYSTEM FATAL MESSAGE 2198, INPUT DATA BLOCK, ***** HAS BEEN PURGED.
- 2199 *** SYSTEM FATAL MESSAGE 2199, SUMMARY/ ONE OR MORE OF THE ABOVE FATAL ERRORS WAS ENCOUNTERED IN SUBROUTINE *****.
- 2200 *** USER FATAL MESSAGE 2200. INCONSISTENT RIGID BODY SYSTEM.
- 2201 *** USER FATAL MESSAGE 2201. REQUIRED DATA BLOCK FOR GINØ FILE, ***, IS PURGED IN SUBROUTINE *****.
- 2202 *** USER FATAL MESSAGE 2202. PARAMETER, ***, HAS ILLEGAL VALUE OF *****.
- 2203 *** USER FATAL MESSAGE 2203. PARAMETER, ***, FOR SUBSTRUCTURE ID ***** INDICATES IT IS AN IDENTICAL SUBSTRUCTURE BUT INPUT DATA BLOCK OF PREVIOUS SUBSTRUCTURE IS PURGED.
- 2204 *** USER FATAL MESSAGE 2204. PARAMETER, ***, HAS A VALUE OF *****, BUT CORRESPONDING INPUT DATA BLOCK, ***, IS NON-PURGED.
- 2205 *** USER WARNING MESSAGE 2205. *** SUBSTRUCTURE HAVE BEEN SPECIFIED. NO WORK CAN BE DONE FOR THIS CASE.
- 2206 *** USER FATAL MESSAGE 2206. PARAMETERS ** AND ** HAVE THE SAME SUBSTRUCTURE ID VALUES.
- 2207 *** USER FATAL MESSAGE 2207. NO SAME DATA SUPPLIED OR GENERATED FOR PVEC RUN - EXECUTION TERMINATED.

DIAGNOSTIC MESSAGES

- 2208 *** USER FATAL MESSAGE 2208. END OF FILE ENCOUNTERED ON GINØ FILE, ***, IN SUBROUTINE *****.
- 2209 *** USER FATAL MESSAGE 2209. END OF RECORD ENCOUNTERED ON GINØ FILE, ***, IN SUBROUTINE *****.
- 2211 *** USER FATAL MESSAGE 2211. LOGIC ERROR IN *****.
- 2213 *** USER FATAL MESSAGE 2213. ILLEGAL SAME DATA. PSEUDOSTRUCTURE CONTAINS INCORRECTLY COUPLED SUBSTRUCTURES.
- 2251 *** USER WARNING MESSAGE 2251. PHYSICALLY UNREALISTIC VALUE FOR NU ON MAT1 CARD *****.
VALUE = *****.
- 2252 *** USER FATAL MESSAGE 2252. GINØ FILE, ***, IS PURGED.
- 2253 *** USER FATAL MESSAGE 2253. ILLEGAL VALUE FOR ONE OR MORE INPUT PARAMETERS - *****
*****).
- 2254 *** USER FATAL MESSAGE 2254. END-OF-FILE ON GINØ FILE ***.
- 2255 *** USER FATAL MESSAGE 2255. GINØ FILE 102 HAS CONTROL RECORD OF LENGTH, ***** / EXPECTED
LENGTH OF CONTROL RECORD IS *****.
- 2256 *** USER FATAL MESSAGE 2256. NON-UNIQUE FIRST GROUP ENTRY. THE TWO GROUPS FOLLOW.
- 2257 *** USER WARNING MESSAGE 2257, SET **** REFERENCED ON SPLINE CARD **** IS EMPTY.

While processing the SET1 or SET2 card referenced on the SPLINEi card, no included grid points were found. If SET1 was used, either no points were included or they were all scalar points. If SET2 was used, the volume of space referenced did not include any structural grid points. This may occur if a tapered element is extended too far. The spline is omitted from the problem and processing continues.

- 2258 *** USER FATAL MESSAGE 2258, SET **** REFERENCED ON SPLINE CARD **** NOT FOUND.

The necessary SET1 or SET2 card was not found. Include the proper set card.

- 2259 *** SYSTEM FATAL MESSAGE 2259, POINT ASSIGNED TO BOX **** FOR CAERO1 **** NOT IN EQAERO.

No internal k point could be found for external box. If box number is okay, module APD is in error; if box number is bad, module GI is in error.

- 2260 *** USER FATAL MESSAGE 2260, SINGULAR MATRIX DEVELOPED WHILE PROCESSING SPLINE ****

Matrix developed by SSPLIN or LSPLIN (depending on type of spline) could not be inverted; possibly for the Surface Spline all points lie in a straight line, or not enough points are included.

NASTRAN SYSTEM AND USER MESSAGES

2261 *** USER FATAL MESSAGE 2261, PLANE OF LINEAR SPLINE **** PERPENDICULAR TO PLANE OF AERO ELEMENT ****

Y-axis of linear spline was perpendicular to connected element and could not be projected onto element.

2262 *** USER FATAL MESSAGE 2262, SPLINE **** INCLUDES AERO BOX INCLUDED ON AN EARLIER SPLINE.

Two splines are attached to the same box. Splines may be connected to the same structural grid point but not the same aerodynamic grid point. This type of error checking will stop with one error, so check this spline and subsequent splines (sorted) for overlaps before resubmitting.

2263 *** USER FATAL MESSAGE 2263, INSUFFICIENT CORE TO PROCESS SPLINE ****

Depending on type of spline and input options, subroutine SSPLIN, or LSPLIN would not have had enough core for this spline. Either allow more core or break this spline into smaller splines.

2264 *** SYSTEM FATAL MESSAGE 2264, NUMBER OF ROWS COMPUTED (****) WAS GREATER THAN SIZE REQUESTED FOR OUTPUT MATRIX (****)

Module ADD determines size of output matrices (j set size). Sum of number of rows added by different method total more than maximum allowed.

2265 *** USER FATAL MESSAGE 2265, METHOD **** FOR AEROELASTIC MATRIX GENERATION IS NOT IMPLEMENTED.

A nonimplemented method for computing these matrices was input.

2266 *** USER FATAL MESSAGE 2266, ONE OR MORE OF THE FOLLOWING FLFACT SETS WERE NOT FOUND *** **

One or more of the FLFACT ID's on the flutter data card could not be found. Include all sets mentioned.

2267 *** USER FATAL MESSAGE 2267, INTERPOLATION METHOD **** UNKNOWN.

Matrix interpolation method on FLUTTER card is not implemented.

2268 *** USER FATAL MESSAGE 2268, FMETHOD SET **** NOT FOUND.

FLUTTER data card for FMETHOD = **** in case control could not be found.

2269 *** USER FATAL MESSAGE 2269, FLUTTER METHOD **** NOT IMPLEMENTED.

Flutter analysis method on FLUTTER data card is not implemented.

2270 *** USER FATAL MESSAGE 2270, LINEAR INTERPOLATION WITHOUT ENOUGH INDEPENDENT MACH NUMBERS EQUAL TO DEPENDENT MACH ****

Linear interpolation is for points with the same Mach number, and less than two more found from the QHHL list which matched the requested Mach on an FLFACT list.

2271 *** USER FATAL MESSAGE 2271, INTERPOLATION MATRIX IS SINGULAR.

Possibly for the surface spline, all the Mach numbers were the same, or for either method, not enough points were included.

DIAGNOSTIC MESSAGES

2288 *** SYSTEM FATAL MESSAGE 2288. **** READ INCORRECT NUMBER WORDS (**** ****).

Subroutine **** read **** words on the **** card which is incorrect.

2289 *** USER FATAL MESSAGE 2289. **** INSUFFICIENT CORE (****). **** = MATERIAL, **** = POINTERS, **** = ELEMENTS, **** = PROPERTIES.

Module ØPTR1 or ØPTR2 gives the open core available and the pointers to the start of each contiguous section of core.

2290 *** USER FATAL MESSAGE 2290. THE FOLLOWING ILLEGAL ELEMENT TYPES FOUND ON PLIMIT CARD.

This message is followed by a list of element types. Processing of legal element types continues so as to discover other errors.

2291 *** USER FATAL MESSAGE 2291, PLIMIT RANGE INCORRECT FOR **** THRU **** AND **** THRU ****.

Property identification numbers are repeated. The first pair is rejected and processing of the remaining ranges continues to discover other errors.

2292 *** USER FATAL MESSAGE 2292. INSUFFICIENT CORE FOR PLIMIT DATA, ELEMENT ****, **** WORDS SKIPPED.

The element type **** being processed exceeded core by **** words. Processing of other element types continues to discover additional requirements.

2293 *** USER FATAL MESSAGE 2293. NO PID ENTRIES ON PLIMIT CARD (****).

A PLIMIT card of element type **** had no property entries.

2294 *** USER FATAL MESSAGE 2294. DUPLICATE **** THRU **** RANGE FOR ELEMENT **** REJECTED PLIMIT. SCAN CONTINUED.

Property identification numbers are repeated for element type ****.

2295 *** USER FATAL MESSAGE 2295. NO ELEMENTS EXIST FOR OPTIMIZATION.

A non-null property card and its corresponding material stress limit is needed. In subroutine ØPT2A stress data is also required.

2296 *** USER FATAL MESSAGE 2296. INSUFFICIENT CORE **** (****), ELEMENT ****.

Subroutine **** has insufficient core when loading element type or number ****. Elements are read into core by element type (see /GPTA1/ sequence) then by sequential element number.

2297 *** SYSTEM FATAL MESSAGE 2297. INCORRECT LOGIC FOR ELEMENT TYPE ****, ELEMENT ****, (****).

Subroutine (****) has sequential element search. Element type can be found in /GPTA1/.

2298 *** USER FATAL MESSAGE 2298. INSUFFICIENT CORE **** (****), PROPERTY ****.

Subroutine **** (core ****) had insufficient core when loading property ****.

NASTRAN SYSTEM AND USER MESSAGES

2299 *** SYSTEM FATAL MESSAGE 2299. INCORRECT LOGIC FOR ELEMENT TYPE ***, PROPERTY **** (****).

Subroutine ØPTP1B has sequential property search. A property card had two entries per card and it was unsorted.

2300 *** SYSTEM FATAL MESSAGE 2300. **** UNABLE TO LOCATE PROPERTY **** ON EPT ØR IN CORE.

2301 *** SYSTEM FATAL MESSAGE 2301. ØPTP1D FILE ØPTIMIZATION PARAMETER INCORRECT AS **** ****.

Check subroutines ØPTPX and ØPTP1D use of the scratch file. In ØPTPR2, the corresponding stress limit(s) is zero.

2302 *** USER FATAL MESSAGE 2302. SUBROUTINE **** HAS NO PROPERTY ØR ELEMENT DATA.

File ØPTP1 has incorrect number of words.

2303 *** USER INFORMATION MESSAGE 2303. ØPTPR2 DETECTED ZERO ALPHA FOR PROPERTY****.

The stress in the element was zero. Only 100 messages per iteration may occur.

2304 *** USER INFORMATION MESSAGE 2304. ØTP2B CONVERGENCE ACHIEVED, HIGHEST VALUE IS ****.

2305 *** USER INFORMATION MESSAGE 2305. ØPTPR2 DETECTED NEGATIVE ALPHA FOR ELEMENT ****.

The element did not have stress data or appropriate material stress limits. The element properties were not changed. Only 100 of these messages will occur per print iteration.

2314 *** USER INFORMATION MESSAGE 2314. STATISTICS FOR SYMMETRIC DECOMPOSITIONS OF DATA BLOCK, ****, FOLLOW / NUMBER OF UII .LT. 0 = **** / MAXIMUM ABSOLUTE VALUE OF AII/UII = 1PE12.5 / N1 THRU N6 = **** / ROW NUMBERS OF 5 LARGEST AII/UII = ****.

This message will appear if the NASTRAN card system(57=1) is placed before the ID card.

2316 *** USER INFORMATION MESSAGE 2316. INSUFFICIENT CORE, TO PREPARE DECOMPOSITION STATISTICS.

2317 *** USER WARNING MESSAGE 2317. PARAM HAS STORED OUTSIDE DEFINED RANGE OF COMMON BLOCK /SYSTEM/. INDEX VALUE = ****.

2318 *** USER FATAL MESSAGE 2318, NO AERØ CARD FOUND.

An AERØ card is required to run APD.

2319 *** USER FATAL MESSAGE 2319, NO CAERØ1 CARDS FOUND.

At least one CAERØ1 card is required for APD.

2320 *** USER FATAL MESSAGE 2320, NO AEFACØ CARDS FOUND.

An AEFACØ has been referenced and none have been found in the input.

DIAGNOSTIC MESSAGES

2321 *** USER FATAL MESSAGE 2321, NO FLUTTER CARDS FOUND.

Flutter analysis requires at least one FLUTTER card.

2322 *** USER FATAL MESSAGE 2322, NEITHER MKAER01 OR MKAER02 CARDS FOUND.

Either MKAER01 or MKAER02 cards are required.

2323 *** USER FATAL MESSAGE 2323, PAER01 CARD NO. XXXXXXX REFERENCED BY CAER01 CARD NO. XXXXXXX BUT DOES NOT EXIST.

CAER01 card points to missing PAER01 card.

2324 *** USER FATAL MESSAGE 2324, CAER01 ELEMENT NO. XXXXXXX REFERENCED ON A SPLINE1 CARD DOES NOT EXIST.

Either a SPLINE1 or a SPLINE2 card references a CAER01 card which is missing.

2325 *** USER FATAL MESSAGE 2325, CAER01 ELEMENT NO. XXXXXXX REFERENCED ON A SET2 CARD DOES NOT EXIST.

A SET2 card points to a CAER01 which was not included.

2326 *** USER FATAL MESSAGE 2326, CAER01 ELEMENT NO. XXXXXXX REFERENCES AEFACT CARD NO. XXXXXXX WHICH DOES NOT EXIST.

The listed CAER01 card requires one AEFACT card for LCHORD or LSPAN.

2327 *** USER FATAL MESSAGE 2327, CAER01 ELEMENT NO. XXXXXXX REFERENCES AEFACT CARD NO. XXXXXXX WHICH DOES NOT EXIST.

The listed CAER01 card requires one AEFACT card for LCHORD or LSPAN.

2328 *** USER FATAL MESSAGE 2328, SET1 AND SPLINE1 CARDS REQUIRED.

At least one SET1 or SET2 card and at least one SPLINE1 or SPLINE2 card required.

2329 *** USER FATAL MESSAGE 2329, DUPLICATE EXTERNAL ID NO. XXXXXXX GENERATED.

The external ID's assigned to each generated box must be unique.

2330 *** USER FATAL MESSAGE 2330, SET1 CARD NO. XXXXXXX REFERENCES EXTERNAL ID NO. XXXXXXX WHICH DOES NOT EXIST.

External ID on SET1 card does not exist as structural grid point.

2331 *** USER FATAL MESSAGE 2331, BOX PICKED ON SPLINE CARD NO. XXXXXXX NOT GENERATED BY CAER0 CARD NO. XXXXXXX.

SPLINE card XXXXXXX points to a box which was not generated by the CAER0 card.

2332A *** USER FATAL MESSAGE 2332. DEPENDENT MPC COMPONENT HAS BEEN SPECIFIED TWICE. SIL VALUE = *****.

2332B *** USER WARNING MESSAGE 2332. INVALID INPUT DATA DETECTED IN DATA BLOCK, ****, PROCESSING STOPPED FOR THIS DATA BLOCK.

NASTRAN SYSTEM AND USER MESSAGES

- 2333 *** USER INFORMATION MESSAGE 2333. MODULE DDRMM TERMINATED WITH VARIABLE IERROR = *****.
- 2334 *** USER WARNING MESSAGE 2334. ILLEGAL MAJOR OR MINOR OFP-ID IDENTIFICATIONS = *****
***** DETECTED IN DATA BLOCK, ****, PROCESSING OF SAID DATA BLOCK DISCONTINUED.
- 2335 *** USER WARNING MESSAGE 2335. THE AMOUNT OF DATA IS NOT CONSISTENT FOR EACH EIGENVALUE IN
DATA BLOCK **** PROCESSING OF THIS DATA BLOCK TERMINATED.
- 2336 *** USER WARNING MESSAGE 2336. A CHANGE IN WORD 2 OF THE OFP-ID RECORDS OF DATA BLOCK
**** HAS BEEN DETECTED. PROCESSING OF THIS DATA BLOCK HAS BEEN TERMINATED.
- 2337 *** USER WARNING MESSAGE 2337. DATA BLOCK **** CAN NOT BE PROCESSED DUE TO A CORE
INSUFFICIENCY OF APPROXIMATELY ***** DECIMAL WORDS.
- 2338 *** USER WARNING MESSAGE 2338. DATA BLOCK **** MAY NOT BE FULLY COMPLETED DUE TO A CORE
INSUFFICIENCY OF APPROXIMATELY ***** DECIMAL WORDS.
- 2339 *** USER WARNING MESSAGE 2339. A CHANGE IN WORD 2 OF THE OFP-ID RECORDS OF DATA BLOCK
**** HAS BEEN DETECTED. PROCESSING OF THIS DATA BLOCK HAS BEEN TERMINATED.
- 2340 *** SYSTEM WARNING MESSAGE 2340. MODULE **** ****, HAS BEEN REQUESTED TO DO UNSYMMETRIC
DECOMPOSITION OF A SYMMETRIC MATRIX.
- 2341 *** USER WARNING MESSAGE 2341. MODULE **** **** HAS BEEN FURNISHED A SQUARE MATRIX MARKED
UNSYMMETRIC FOR SYMMETRIC DECOMPOSITION.
- 2342 *** USER WARNING MESSAGE 2342. UNRECOGNIZED DMAP APPROACH PARAMETER = **** ****.
- 2343 *** SYSTEM WARNING MESSAGE 2343. DATA BLOCK, ****, IS EITHER NOT -EQEXIN- OR POSSIBLY
INCORRECT.
- 2344 *** SYSTEM WARNING MESSAGE 2344. GPFDR FINDS ELEMENT = **** ****, HAS AN ECT ENTRY
LENGTH TOO LONG FOR A PROGRAM LOCAL ARRAY.
- 2345 *** SYSTEM WARNING MESSAGE 2345. GPFDR FINDS AND IS IGNORING UNDEFINED ECT DATA WITH
LOCATE NUMBERS = ***** ***** *****.
- 2346 *** SYSTEM WARNING MESSAGE 2346. GPFDR FINDS DATA FOR EL-TYPE = *****, IN DATA
BLOCK, ***** NOT TO BE IN AGREEMENT WITH THAT WHICH IS EXPECTED.
- 2347 *** SYSTEM WARNING MESSAGE 2347. GPFDR FINDS TOO MANY ACTIVE CONNECTING GRID POINTS FOR
ELEMENT ID = *****.
- 2348 *** SYSTEM WARNING MESSAGE 2348. GPFDR DOES NOT UNDERSTAND THE MATRIX-DICTIONARY ENTRY
FOR ELEMENT ID = *****.

DIAGNOSTIC MESSAGES

- 2349 *** SYSTEM WARNING MESSAGE 2349. GPFDR FINDS AN ELEMENT ENTRY CONNECTING PIVOT SIL = ***** , ON DATA BLOCK ***** TOO LARGE FOR A LOCAL ARRAY. ENTRY IS BEING IGNORED.
- 2350 *** SYSTEM WARNING MESSAGE 2350. GPFDR CANNOT FIND PIVOT SIL = ***** , AMONG THE SILS OF ELEMENT ID = ***** AS READ FROM DATA BLOCK, ***** , ENTRY THUS IGNORED.
- 2351 *** USER INFORMATION MESSAGE 2351. A FORCE CONTRIBUTION DUE TO ELEMENT TYPE = **** , ON POINT ID = ***** , WILL NOT APPEAR IN THE GRID-POINT-FORCE-BALANCE SUMMARY.
- 2352 *** SYSTEM WARNING MESSAGE 2352. GPFDR IS NOT ABLE TO FIND PIVOT SIL = ***** AS READ FROM DATA BLOCK ***** IN TABLE OF SILS.
- 2353 *** USER WARNING MESSAGE 2353. INSUFFICIENT CORE TO HOLD ALL NON-ZERO APP-LOAD AND F-OF-SPC OUTPUT LINE ENTRIES OF GRID-POINT-FORCE-BALANCE REQUESTS. SOME POINTS REQUESTED FOR OUTPUT WILL BE MISSING THEIR APP-LOAD OR F-OF-SPC CONTRIBUTION IN THE PRINTED BALANCE.
- 2354 *** USER WARNING MESSAGE 2354. GPFDR MODULE IS UNABLE TO CONTINUE AND HAS BEEN TERMINATED DUE TO ERROR MESSAGE PRINTED ABOVE OR BELOW THIS MESSAGE. THIS ERROR OCCURRED IN GPFDR CODE WHERE THE VARIABLE -NERROR- WAS SET = *****.
- 2355 *** USER FATAL MESSAGE 2355, GRID POINT COORDINATES OF ELEMENT ***** ARE IN ERROR. ONE OR MORE OF THE R-COORDINATES ARE ZERO OR NEGATIVE.
- 2357 *** USER WARNING MESSAGE 2357. ONE VECTOR (DEFAULT) WILL BE COMPUTED IN THE COMPLEX REGION.
- If more than one vector is desired from the Hessenburg method, make a specific request on the EIGC card.
- 2358 *** USER WARNING MESSAGE 2358, SYMMETRIC SCRIPT-AF MATRIX (HREE) ASSUMED IN RADMTX.
- 2359 *** USER WARNING MESSAGE 2359, COL ***** , ROW ***** OF RADMTX IS NEGATIVE.
- 2360 *** USER FATAL MESSAGE 2360, TOTAL VIEW FACTOR (FA/A), FOR ELEMENT ***** IS ***** (ELEMENT AREA IS *****).
- Provides view factors and areas for all elements with a view factor greater than 1.01. This message is also a WARNING for all elements with a view factor between .99 and 1.01 provided the NASTRAN card, SYSTEM(58)=1, is included in the deck.
- 2361 *** USER INFORMATION MESSAGE 2361, **** ELEMENTS HAVE A TOTAL VIEW FACTOR (FA/A) LESS THAN 0.99, ENERGY MAY BE LOST TO SPACE.
- Provides the total number of elements with a view factor less than .99.
- 2362 *** USER FATAL MESSAGE 2362, CHBDY CARDS WITH DUPLICATE IDS FOUND IN EST, CHBDY ID NUMBER = *****.
- 2364 *** USER FATAL MESSAGE 2364, GRID POINT COORDINATES OF ELEMENT ***** ARE IN ERROR. ONE OR MORE OF THE THETA-COORDINATES ARE NONZERO.

NASTRAN SYSTEM AND USER MESSAGES

2365 *** USER WARNING MESSAGE 2365, INSUFFICIENT CORE FOR HESSENBURG METHOD. SWITCHING TO INVERSE POWER.

2366 *** USER FATAL MESSAGE 2366, REGION IMPROPERLY DEFINED ON EIGC CARD.

If insufficient core has caused an automatic switch from Hessenburg method to Inverse Power Method, the EIGC card must have the region(s) defined (they are ignored for the Hessenburg method). Either increase core to use the Hessenburg method or define the region(s) for Inverse Power.

2367 *** USER WARNING MESSAGE 2367, FREQUENCY F1 (FIELD 4) ON THE EIGR BULK DATA CARD IS NEGATIVE. IT IS ASSUMED TO BE ZERO FOR CALCULATION PURPOSES.

2382 *** USER WARNING MESSAGE 2382, ELEMENT MATRICES FOR ELEMENTS CONGRUENT TO ELEMENT ID = ***** WILL BE RE-COMPUTED AS THERE IS INSUFFICIENT CORE AT THIS TIME TO HOLD CONGRUENCY MAPPING DATA.

2383 *** SYSTEM WARNING MESSAGE 2383, UNABLE TO LOCATE CONGRUENCY MAPPING DATA FOR ELEMENT ID = *****. ELEMENT MATRICES FOR THIS ELEMENT WILL, THEREFORE, BE RE-COMPUTED.

2384 *** USER WARNING MESSAGE 2384, CONGRUENCY OF ELEMENT ID = ***** WILL BE IGNORED AND ITS ELEMENT MATRICES WILL BE RE-COMPUTED AS THERE IS INSUFFICIENT CORE AT THIS TIME TO PERFORM CONGRUENCY MAPPING COMPUTATIONS.

DIAGNOSTIC MESSAGES

- 3001 *** SYSTEM FATAL MESSAGE 3001, ATTEMPT TO OPEN DATA SET *** IN SUBROUTINE ***** WHICH WAS NOT DEFINED IN FIST.
Subroutine did not expect data block to be purged. Check data block requirements for module. This message is also a WARNING when STRESS output is requested in a heat transfer problem.
- 3002 *** SYSTEM FATAL MESSAGE 3002, EOF ENCOUNTERED WHILE READING DATA SET ***** (FILE ***) IN SUBROUTINE *****.
This message is issued when an End-Of-File occurs while trying to skip the header record. The data block is not in the proper format.
- 3003 *** SYSTEM FATAL MESSAGE 3003, ATTEMPT TO READ PAST THE END OF A LOGICAL RECORD IN DATA SET ***** (FILE ***) IN SUBROUTINE *****.
This message is issued when the file is positioned at the beginning of a logical record and the record does not contain at least three words. Data block is not in proper format.
- 3004 *** SYSTEM FATAL MESSAGE 3004, INCONSISTENT TYPE FLAGS ENCOUNTERED WHILE PACKING DATA SET ****.
- 3005 *** USER FATAL MESSAGE 3005, ATTEMPT TO OPERATE ON SINGULAR MATRIX **** IN SUBROUTINE ****.
A diagonal term does not exist for a column of (U). This is normally detected in DECIMP implying care was not taken in processing singular matrices in the calling routine.
- 3006 *** SYSTEM FATAL MESSAGE 3006, BUFFER ASSIGNED WHEN OPENING DATA BLOCK **** FILE (****) CONFLICTS WITH BUFFERS CURRENTLY OPEN.
Computation of buffer pointers or allocation of open core is in error.
- 3007 *** SYSTEM FATAL MESSAGE 3007, ILLEGAL INPUT TO SUBROUTINE ****.
Subroutine **** has encountered data which it cannot process. This error should not be caused by user input data. A system or programming error is indicated. Go directly to the subroutine listing or description to determine the exact cause of the problem.
- 3008 *** SYSTEM FATAL MESSAGE 3008, INSUFFICIENT CORE AVAILABLE FOR SUBROUTINE *****.
This message implies that the particular subroutine does not have sufficient core to meet its demands. The subroutine or module description should be consulted to determine the core requirements.
- 3009 *** SYSTEM FATAL MESSAGE 3009, DATA TRANSMISSION ERROR ON DATA SET ***** (FILE ***) .
A conflict exists between the SGINO subroutine for the UNIVAC 1108 and the resident NTRAN\$. Either recode SGINO or remove the PLOT request from the NASTRAN job.
- 3010 *** SYSTEM FATAL MESSAGE 3010, ATTEMPT TO MANIPULATE DATA SET ***** (FILE ***) BEFORE OPENING FILE.
An operation other than OPEN or CLOSE is requested on a file which is not defined in the FIST.

NASTRAN SYSTEM AND USER MESSAGES

3011 *** SYSTEM FATAL MESSAGE 3011, ATTEMPT TO WRITE A TRAILER ON FILE *** WHEN IT HAS BEEN PURGED.

The file did not exist in the FIST when WRTTRL was called.

3012 *** SYSTEM FATAL MESSAGE 3012, ATTEMPT TO OPEN DATA SET ***** (FILE ***) WHICH HAS ALREADY BEEN OPENED.

GINO OPEN was called while the file was already open.

3013 *** SYSTEM FATAL MESSAGE 3013, ATTEMPT TO READ DATA SET ***** (FILE ***) WHEN IT WAS OPENED FOR OUTPUT.

GINO was called to READ a data block opened for output.

3014 *** SYSTEM FATAL MESSAGE 3014, ATTEMPT TO WRITE DATA SET ***** (FILE ***) WHEN IT WAS OPENED FOR INPUT.

GINO was called to WRITE a data block opened for input.

3015 *** SYSTEM FATAL MESSAGE 3015, ATTEMPT TO FWDREC ON DATA SET ***** (FILE ***) WHEN IT WAS OPENED FOR OUTPUT.

GINO was called to FWDREC a file opened for output.

3016 *** SYSTEM FATAL MESSAGE 3016, *** MATRIX IS NOT IN PROPER FORM IN SUBROUTINE ***.

This implies that the input matrix is not in the proper form or type acceptable to the subroutine. Check the trailer information on the matrix and the subroutine description for the discrepancy.

3017 *** USER WARNING MESSAGE 3017, ONE OR MORE GRID POINT SINGULARITIES HAVE NOT BEEN REMOVED BY SINGLE OR MULTI-POINT CONSTRAINTS.

Singularities or near singularities may exist at the grid point level. The listed singularities should be examined for data errors. The check performed here is neither necessary nor sufficient for a singular matrix.

3018 *** SYSTEM FATAL MESSAGE 3018, MODULE *****, SEQUENCE NO. ***, REQUIREMENTS EXCEED AVAILABLE FILES.

Segment File Allocator (SFA) did not have sufficient logical files available to fill the request of the module. Cut module requirements or increase the logical files within the computer system. See Section 5 of the Programmer's Manual.

3019 *** USER FATAL MESSAGE 3019, MAXIMUM LINE COUNT EXCEEDED IN SUBROUTINE **** LINE COUNT EQUALS ****.

The total number of lines written on the system output file has exceeded the set limit (default value is 20,000). If you wish to increase this value, include a card of the form "MAXLINES=n" in your Case Control Deck.

3020 *** SYSTEM FATAL MESSAGE 3020, GNFIST OVERFLOWED FIST TABLE AT SEQUENCE NO. *** DATA SET *****.

Generate FIST (GNFIST) routine overflowed FIST /XFIST/. Increase compiled size. See Section 2 of the Programmer's Manual.

DIAGNOSTIC MESSAGES

3021 *** SYSTEM FATAL MESSAGE 3021, FILE *** NOT DEFINED IN FIST.

An operation other than OPEN or CLOSE is requested on a file which is not defined in the FIST.

3022 *** SYSTEM WARNING MESSAGE 3022, DATA SET ***** IS REQUIRED AS INPUT AND IS NOT OUTPUT BY A PREVIOUS MODULE IN THE CURRENT DMAP ROUTE.

Segment File Allocator (SFA) detected that an input data block to a future module has not been generated. If the future module requires that this data block exist, the module may terminate with a fatal error.

This message may occur (and most often does) when the Segment File Allocator has removed from its tables (due to a need for more room) previously purged data blocks. In this case no error or even a warning is implied.

3023 *** USER INFORMATION MESSAGE 3023--PARAMETERS FOR SYMMETRIC DECOMPOSITION OF DATA BLOCK
 ***** (N = *****) TIME ESTIMATE = *****
 C AVG = ***** S AVG = ***** PC MAX = *****
 PC AVG = ***** ADDITIONAL CORE = ***** PC GROUPS = *****
 SPILL GROUPS = ***** C MAX = ***** PREFACE LOOPS = *****

N is the number of rows in the data block; TIME is the estimate (in seconds) to perform the decomposition; C AVG is the average number of active columns per pivot row; PC AVG is the average number of passive columns at each active termination point; SPILL GROUPS is the number of spill groups; S AVG is the average number of rows in each spill group; ADDITIONAL CORE (positive) is the amount of core required to avoid spill, (negative) is the amount of unused core; C MAX is the maximum number of active columns in any one pivot row; PC MAX is the maximum number of passive columns at any one active column termination point; PC GROUPS is the number of active column termination points; PREFACE LOOPS is the number of times the preface of the decomposition subroutine is executed.

3024 *** USER INFORMATION MESSAGE 3024, THE BANDWIDTH OF MATRIX **** EXCEEDS THE MAXIMUM BANDWIDTH. A MAXIMUM BANDWIDTH OF **** WILL BE USED.

This message indicates that a matrix has scattered terms way off the diagonal (i.e., a large bandwidth). Instead of searching all combinations of B and C, the search is started at the maximum bandwidth.

3025 *** SYSTEM FATAL MESSAGE 3025, ILLEGAL INDEX IN ACTIVE ROW OR COLUMN CALCULATION IN ****.

Possible machine error. Rerun problem. If error persists, a code error exists in the decomposition routine.

3026 *** SYSTEM FATAL MESSAGE 3026, MATRIX **** EXCEEDS MAXIMUM ALLOWABLE SIZE FOR BANDWIDTH PLUS ACTIVE COLUMNS. BMAX = ****, CMAX = ****.

Sufficient space was not reserved for the generation of the B vs. C vector. SDCOMP should be recompiled to increase BMAX and CMAX.

3027 *** USER INFORMATION MESSAGE 3027, **** DECOMPOSITION TIME ESTIMATE IS ***** SECONDS.

Gives the estimated time required for a decomposition in seconds and the type of matrix, i.e., complex, real (double or single precision), symmetric or unsymmetric.

NASTRAN SYSTEM AND USER MESSAGES

3028 *** USER INFORMATION MESSAGE 3028, B = ****, BBAR = ****, C = ****, CBAR = ****, R = ****.

Gives the upper bandwidth (B), lower bandwidth (BBAR), number of active columns (C), and active rows (CBAR) used in the unsymmetric decomposition.

3029 *** SYSTEM FATAL MESSAGE 3029, PHYSICAL END-OF-FILE ENCOUNTERED ON DATA SET **** (FILE ****).

Since logical End-of-Files are used by GINØ, a physical End-of-File indicates an attempt to read beyond valid data.

3030 *** USER WARNING MESSAGE 3030, ØFP UNABLE TO PROCESS DATA BLOCK. A TABLE ØF THE DATA BLOCK FØLLØWS.

NASTRAN SYSTEM AND USER MESSAGES

3031 Same as message 3032.

3032 *** USER FATAL MESSAGE 3032, UNABLE TO FIND SELECTED SET (****) IN TABLE (****) IN SUBROUTINE (****).

A particular set used in the problem was not included in the data. Good examples are loads, initial conditions, or frequency sets. Include the required data or change the Case Control Deck to select data already in problem. Set zero (0) has a special meaning. A set selection was required, but none was made. For example, no METHOD was selected for an eigenvalue extraction problem.

This message can also indicate that a LOAD card has referenced another LOAD card, which is not permitted.

3033 *** USER FATAL MESSAGE 3033, SUBCASE ID **** IS REFERENCED ON ONE OR MORE RANDPS CARDS BUT IS NOT A CURRENT SUBCASE ID.

The RANDPS set selected can only reference subcase identification numbers included in the current loop. All subcases in which the direct input matrices or transfer functions do not change are run together. Either add a subcase with referenced identification number, change your RANDPS cards or change the identification numbers on your current subcases.

3034 *** USER WARNING MESSAGE 3034, ORTHOGONALITY CHECK FAILED, LARGEST TERM = **** EPSI = ****.

The off-diagonal terms of the modal mass matrix are larger than the user input criteria on the EIGB or EIGR bulk data card. The eigenvectors are not orthogonal to this extent. This nonorthogonality is especially important if a modal formulation is contemplated.

3035 *** USER INFORMATION MESSAGE 3035, FOR LOAD ** EPSILON SUB E=*****.

This is an informative message reflecting the accumulated round-off error of the static solution.

3036 *** SYSTEM FATAL MESSAGE 3036, DATA SET ***** IS REQUIRED AS INPUT BUT HAS NOT BEEN GENERATED OR PURGED.

The above mentioned data set is not accounted for on the DPTP checkpoint dictionary. The message indicates a failure of the File Name Table. As an interim measure the user can use the ALTER feature to execute the proper module to create the needed data set.

3037 *** SYSTEM FATAL MESSAGE 3037, JOB TERMINATED IN SUBROUTINE ****.

This message designates the subroutine in which the program terminated. It should be preceded by a user message which explains the cause of the termination. The module in which the program terminated can be found by examining the online time messages.

3038 *** SYSTEM FATAL MESSAGE 3038, DATA SET *** DOES NOT HAVE MULTIREEL CAPABILITY.

Computer hardware/software does not support multireel files.

3039 *** SYSTEM FATAL MESSAGE 3039, ENDSYS CANNOT FIND SAVE FILE.

File cannot be found to save and restore executive tables during link switching.

3040 *** SYSTEM FATAL MESSAGE 3040, ATTEMPT TO WRITE DATA SET ***** (FILE ***) WHEN IT IS AN INPUT FILE.

Input data blocks for a module (100 .LT. NAME .LT. 200) may be read only.

DIAGNOSTIC MESSAGES

3041 *** USER WARNING MESSAGE 3041, EXTERNAL GRID POINT *** DOES NOT EXIST OR IS NOT A GEOMETRIC GRID POINT. THE BASIC ORIGIN WILL BE USED.

The reference grid point specified on the PARAM GRDPNT card for weight and balance calculations in GPWG cannot be used.

3042 *** USER WARNING MESSAGE 3042, INCONSISTENT SCALAR MASSES HAVE BEEN USED. EPSILON/DELTA = *****.

The GPWG has detected inconsistent scalar masses. Direct masses have been used. Skew inertia's will result. Examine your scalar masses and CONM1 cards.

3043 *** USER FATAL MESSAGE 3043, UNCONNECTED EXTRA POINT (MODAL COORDINATE=****) HAS BEEN DETECTED BY SUBROUTINE ****.

Extra points must be connected via Direct Matrix Input (or Transfer Functions) in modal transient or frequency response.

3044 *** USER FATAL MESSAGE 3044, A POINT ON NONLINEAR LOAD SET **** NOLIN **** IS NOT AN EXTRA POINT. ONLY EXTRA POINTS MAY HAVE NONLINEAR LOADS IN A MODAL FORMULATION.

Modal transient analysis (Rigid Format D-12) will support nonlinear loads only on extra points. Pick another nonlinear load set.

3045 *** USER WARNING MESSAGE 3045, INSUFFICIENT TIME TO COMPLETE THE REMAINING ** SOLUTION(S) IN MODULE ***.

The time specified on the NASTRAN TIME card has expired in the named module. The module will be terminated. NASTRAN will continue running until the time on the job card expires. Restart to obtain print-out, complete solutions or rerun problem.

3046 *** USER FATAL MESSAGE 3046, YOUR SELECTED LOADING CONDITION, INITIAL CONDITION, AND NONLINEAR FORCES ARE NULL. A ZERO SOLUTION WILL RESULT.

Transient solution must have one of the above nonzero.

3047 *** USER FATAL MESSAGE 3047, NO MODES WITHIN RANGE AND LMODES=0. A MODAL FORMULATION CANNOT BE MADE.

The modes used for a modal formulation must be selected by a PARAM card. Set LFREQ, HFREQ or LMODES to request modes.

3048 *** SYSTEM FATAL MESSAGE 3048, BUFFER CONTROL WORD INCORRECT FOR GIN0 **** OPERATION ON DATA BLOCK ****.

The buffer control word has been destroyed outside of GIN0 or an attempt to READ a file opened to WRITE or similar error has occurred.

3049 *** SYSTEM FATAL MESSAGE 3049, GIN0 UNABLE TO POSITION DATA BLOCK **** CORRECTLY DURING **** OPERATION.

A block number read does not match the expected block number. The file has been repositioned outside the GIN0 environment or a machine or operating system error has occurred.

3050 *** USER FATAL MESSAGE 3050, INSUFFICIENT TIME REMAINING FOR DECOMPOSITION, ****. TIME ESTIMATE IS **** SECONDS.

The time estimated for a decomposition exceeds the remaining time. Increase the time estimate for the run.

NASTRAN SYSTEM AND USER MESSAGES

3051 *** USER FATAL MESSAGE 3051, INITIAL CONDITION SET **** WAS SELECTED FOR A MODAL TRANSIENT PROBLEM. INITIAL CONDITIONS ARE NOT ALLOWED IN SUCH A PROBLEM.

3052 *** USER WARNING MESSAGE 3052, A RANDOM REQUEST FOR CURVE TYPE - **** -, POINT - **** COMPONENT - **** -, SPECIFIES TOO LARGE A COMPONENT ID. THE LAST COMPONENT WILL BE USED.

3053 *** USER WARNING MESSAGE 3053, THE ACCURACY OF EIGENVALUE **** IS IN DOUBT. GIVENS-QR FAILED TO CONVERGE IN **** ITERATIONS.

Each eigenvalue is computed to the precision limits of each machine consistent with the maximum number of iterations allowed. A programming change would be required to increase the maximum iteration parameter.

3054 *** USER WARNING MESSAGE 3054, THE ACCURACY OF EIGENVECTOR **** CORRESPONDING TO THE EIGENVALUE **** IS IN DOUBT.

The eigenvector failed to converge in the allowable number of iterations. Particular attention should be given to the off-diagonal terms of the modal mass matrix (MI) to determine if this vector is orthogonal to the remaining vectors. These terms will be computed and checked if field 9 on the EIGR card contains a nonzero value. The message is expected in the case of close or multiple eigenvalues, even though the vectors are properly computed.

3055 *** USER FATAL MESSAGE 3055, AN ATTEMPT TO MULTIPLY OR MULTIPLY AND ADD NON-CONFORMABLE MATRICES TOGETHER WAS MADE IN MODULE *****.

The multiply/add subroutine requires conformable matrices. There are two possible equations

$$1. [X] = [A][B] + [C]$$

The number of columns of [A] must be equal to the number of rows of [B] and the number of columns of [C] must be equal to the number of columns of [B] and the number of rows of [C] must be equal to the number of rows of [A].

$$2. [X] = [A]^T[B] + [C]$$

The number of rows of [A] must be equal to the number of rows of [B]; the number of columns of [C] must be equal to the number of columns of [B] and the number of rows of [C] must be equal to the number of columns of [A].

3056 *** USER FATAL MESSAGE 3056, NO MASS MATRIX IS PRESENT BUT MASS DATA IS REQUIRED.

An operation with the mass matrix is required, such as a gravity loading condition, but none was created. A typical cause is the omission of RH0 on the MAT1 card.

3057 *** USER FATAL MESSAGE 3057, MATRIX **** IS NOT POSITIVE DEFINITE.

A Cholesky decomposition was attempted on the above matrix, but a diagonal term was negative or equal to zero, such that the decomposition failed.

DIAGNOSTIC MESSAGES

3058 *** USER WARNING MESSAGE 3058, EPSILON IS LARGER THAN **** FOR SUBCASE ****.

The error residual (either ϵ_ℓ or ϵ_ϕ)

$$\epsilon = \frac{\{u\}^T \{\delta P\}}{\{P\}^T \{u\}} \quad \text{is larger than would be expected for}$$

a well conditioned problem. Near singularities may exist.

3059 *** USER FATAL MESSAGE 3059, SET IDENTIFIER **** DOES NOT EXIST. ERROR DETECTED IN SUBROUTINE ****.

When describing displacement matrices only those set identifier (such as M or G) listed in DMAP module MATGPR are legal set descriptors. Choose a set descriptor which is legal (and describes the matrices to be operated on).

3060 *** USER FATAL MESSAGE 3060, SUBROUTINE ***** - OPTION **** NOT IN APPROVED LIST.

3061 *** USER INFORMATION MESSAGE 3061, THE MEASURE OF NON-PLANARITY IS **** FOR ELEMENT NUMBER *****.

The measure of non-planarity for isoparametric quadrilateral membrane elements is the distance from actual grid points to mean plane divided by the average length of the diagonals. This message is issued only when the absolute value of this measure is greater than .01.

3062 *** SYSTEM FATAL MESSAGE 3062, HMAT MATERIAL ROUTINE CALLED IN A NON-HEAT-TRANSFER PROBLEM.

3063 *** SYSTEM WARNING MESSAGE 3063, INPUT FORCES DATSDRHA BLOCK DOES NOT HAVE CORRECT DATA.

3064 *** SYSTEM WARNING MESSAGE 3064, INCONSISTENT HBDY DATA RECORDS. *****

3065 *** SYSTEM WARNING MESSAGE 3065, THERE IS NO EST DATA FOR HBDY ELEMENT ID = *****.

3066 *** USER WARNING MESSAGE 3066, THERE IS NO TL0AD1 OR TL0AD2 DATA FOR LOAD-ID = *****.

3067 *** USER WARNING MESSAGE 3067, LOAD SET ID = ***** IS NOT PRESENT.

3068 *** SYSTEM WARNING MESSAGE 3068, UNRECOGNIZED CARD TYPE = ***** FOUND IN -SLT- DATA BLOCK.

3069 *** USER WARNING MESSAGE 3069, OUTPUT DATA BLOCK FOR FORCES IS PURGED.

3070 *** USER WARNING MESSAGE 3070, QGE IS REQUIRED BY THIS MODULE AND IS PURGED. NO OUTPUT FILE HAS BEEN CREATED.

3071 *** SYSTEM WARNING MESSAGE 3071, EXTRA DATA IN RADLST RECORD OF MATPOOL DATA BLOCK IGNORED.

3072 *** USER WARNING MESSAGE 3072, TOO MANY MATRIX VALUES INPUT VIA RADMTX BULK DATA FOR COLUMN ***** EXTRA VALUES IGNORED AS MATRIX SIZE IS DETERMINED TO BE OF SIZE ***** FROM RADLST COUNT OF ELEMENT ID-S.

NASTRAN SYSTEM AND USER MESSAGES

3073 *** USER FATAL MESSAGE 3073, NO -HBDY- ELEMENT SUMMARY DATA IS PRESENT FOR ELEMENT ID = ***** , WHICH APPEARS ON A -RADLST- BULK DATA CARD.

3074 *** USER FATAL MESSAGE 3074, COLUMN ***** OF THE Y MATRIX IS NULL.

3075 *** USER FATAL MESSAGE 3075, INTERMEDIATE MATRIX Y IS SINGULAR.

3076 *** SYSTEM FATAL MESSAGE 3076, GPTT DATA IS NOT IN SORT BY INTERNAL ID.

3077 *** USER FATAL MESSAGE 3077, THERE IS NO GRID POINT TEMPERATURE DATA OR DEFAULT TEMPERATURE DATA FOR SIL POINT ***** AND POSSIBLY OTHER POINTS.

3078 *** USER FATAL MESSAGE 3078, NO GPTT DATA IS PRESENT FOR TEMPERATURE SET *****.

3079 *** USER FATAL MESSAGE 3079, THERE ARE NO -HBDY- ELEMENTS PRESENT.

3080 *** USER FATAL MESSAGE 3080, INTEGER VALUES OF EMISSIVITY ENCOUNTERED ***** ELEMENT ID = *****.

3081 *** SYSTEM FATAL MESSAGE 3081, INCONSISTENT USET DATA DETECTED.

3082 *** USER WARNING MESSAGE 3082, M = ***** , N = *****.

More than one n-set degree-of-freedom is associated with an m-set degree-of-freedom. The term associated with the m-n indices given in the message is ignored.

3083 *** USER FATAL MESSAGE 3083, UM POSITION = ***** , SIL = *****.

An m-set degree-of-freedom is not expressed in terms of an n-set degree-of-freedom.

3084 *** USER FATAL MESSAGE 3084, THERE IS NO TEMPERATURE DATA FOR SIL NUMBER *****.

3085 *** USER FATAL MESSAGE 3085, THE PF LOAD VECTOR IS EITHER PURGED OR NULL.

3086 *** USER INFORMATION MESSAGE 3086, ENTERING SSGHT EXIT MODE BY REASON NUMBER 1 (NORMAL CONVERGENCE).
(1)

3086 *** USER INFORMATION MESSAGE 3086, ENTERING SSGHT EXIT MODE BY REASON NUMBER 2 (MAXIMUM ITERATIONS).
(2)

3086 *** USER INFORMATION MESSAGE 3086, ENTERING SSGHT EXIT MODE BY REASON NUMBER 3 (DIVERGING SOLUTION).
(3)

3086 *** USER INFORMATION MESSAGE 3086, ENTERING SSGHT EXIT MODE BY REASON NUMBER 4 (INSUFFICIENT TIME).
(4)

3086 *** USER INFORMATION MESSAGE 3086, ENTERING SSGHT EXIT MODE BY REASON NUMBER 5 (MAXIMUM CONVERGENCE).
(5)

DIAGNOSTIC MESSAGES

1. Normal convergence occurs when the solution meets the convergence criteria defined by the parameter EPSHT.
2. Iterations are terminated when the number defined by the parameter MAXIT is attained.
3. Iterations are terminated when the solution diverges.
4. Iterations are terminated when there is insufficient time to complete the next loop.
5. Iterations are terminated when there is no change to the solution vector but the parameter EPSHT criteria was not met.

3087 *** USER FATAL MESSAGE 3087, TEMPERATURE SET ***** IS NOT PRESENT IN GPTT DATA BLOCK.

3088 *** USER FATAL MESSAGE 3088, ILLEGAL GEOMETRY FOR REVOLUTION ELEMENT ****.

3089 *** USER FATAL MESSAGE 3089, ILLEGAL GEOMETRY FOR TRIANGLE ELEMENT ****.

3090 *** USER FATAL MESSAGE 3090, ILLEGAL GEOMETRY FOR QUAD. ELEMENT ****.

3091 *** SYSTEM WARNING MESSAGE 3091, A TRAPRG ELEMENT = ***** DOES NOT HAVE SIDE 1-2 PARALLEL TO SIDE 3-4.

3092 *** USER FATAL MESSAGE 3092, TRIRG OR TRAPRG ELEMENT = ***** POSSESSES ILLEGAL GEOMETRY.

3093 *** SYSTEM FATAL MESSAGE 3093, ELEMENT = ***** REASON = *****.

1. Less than 2 points have been referenced.
2. Unable to locate SIL value.
3. Unrecognized form for element.
4. Illegal number of points for this form of the element.
5. Illegal number of points for this form of the element.

3094 *** SYSTEM FATAL MESSAGE 3094, SLT LOAD TYPE ***** IS NOT RECOGNIZED.

3095 *** USER WARNING MESSAGE 3095, ELEMENT TYPE ***** WITH ID = *****, AND APPEARING ON EITHER A QVECT, QBDY1, QBDY2, OR QVOL LOAD CARD HAS THE SAME ID AS AN ELEMENT OF ANOTHER TYPE AND IS NOT BEING USED FOR LOADING.

3096 *** USER FATAL MESSAGE 3096, ELEMENT ID = ***** AS REFERENCED ON A QVOL, QBDY1, QBDY2, OR QVECT LOAD CARD COULD NOT BE FOUND AMONG ACCEPTABLE ELEMENTS FOR THAT LOAD TYPE.

3097 *** USER FATAL MESSAGE 3097, COLUMN ***** IS SINGULAR. UNSYMMETRIC ***** DECOMP ABORTED.

USER FATAL MESSAGE 3097, COLUMN ***** IS SINGULAR. SYMMETRIC ***** DECOMP ABORTED.

When a matrix being read in is singular (null column or for symmetric decomposition a zero diagonal) the internal column number and type of decomposition is identified. The message does not appear for special cases such as less than three columns or for proportional rows.

3098 *** USER FATAL MESSAGE 3098, QDMEM2 ELEMENT STIFFNESS ROUTINE DETECTS ILLEGAL GEOMETRY FOR ELEMENT ID = *****.

NASTRAN SYSTEM AND USER MESSAGES

- 3099 *** USER FATAL MESSAGE 3099, ELEMENT STIFFNESS COMPUTATION FOR QDMEM2 ELEMENT ID =
***** IS IMPOSSIBLE DUE TO SINGULARITY IN CONSTRAINT EQUATION.
- 3100 *** USER WARNING MESSAGE 3100, ELEMENT THERMAL LOAD COMPUTATION FOR QDMEM2 ELEMENT ID =
***** FINDS ILLEGAL GEOMETRY THUS NO LOADS OUTPUT FOR ELEMENT-ID NOTED.
- 3101 *** USER WARNING MESSAGE 3101, SINGULARITY OR BAD GEOMETRY FOR QDMEM2 ELEMENT ID =
***** STRESS OR FORCES WILL BE INCORRECT.
- 3102 (1) *** SYSTEM FATAL MESSAGE 3102. LOGIC ERROR EMA- ****.
- 3102 (2) *** USER WARNING MESSAGE 3102, SUBROUTINE TRHTIC, UNSTABLE TEMP. VALUE OF *****
****, COMPUTED FOR TIME STEP ***** AT POINT NUMBER ***** IN THE ANALYSIS STEP.
- 3103 (1) *** USER WARNING MESSAGE 3103. EMGCOR OF EMG MODULE FINDS EITHER OF DATA BLOCKS **** OR
**** ABSENT AND THUS ****, MATRIX WILL NOT BE FORMED.
- 3103 (2) *** USER FATAL MESSAGE 3103, SUBROUTINE TRHTIC TERMINATING DUE TO ERROR COUNT FOR
MESSAGE 3102.
- This occurs for 10 errors detected in the temperature computation.
- 3104 *** SYSTEM WARNING MESSAGE 3104. EMGCOR FINDS SET (ASSUMED DATA BLOCK *****) MISSING. EMG
MODULE COMPUTATIONS LIMITED.
- 3105 *** SYSTEM FATAL MESSAGE 3105. EMGPR0 FINDS ELEMENT OF TYPE = ***** UNDEFINED
IN EST DATA BLOCK AND/OR ELEMENT ROUTINE.
- 3106 *** SYSTEM FATAL MESSAGE 3106. EMGPR0 FINDS THAT ELEMENT TYPE ***** HAS EST ENTRIES
TOO LARGE TO HANDLE CURRENTLY.
- 3107 *** SYSTEM INFORMATION MESSAGE 3107. EMGOLD IS PROCESSING ELEMENTS OF TYPE = ***, BEGINNING
WITH ELEMENT ID = *****.
- 3108 *** SYSTEM FATAL MESSAGE 3108. EMGOUT RECEIVES ILLEGAL FILE TYPE = *****.
- 3109 *** SYSTEM FATAL MESSAGE 3109. EMGOUT HAS BEEN SENT AN INVALID DICTIONARY WORD-2 = *****
FROM ELEMENT ID = *****.
- 3110 *** SYSTEM FATAL MESSAGE 3110. EMGOUT HAS BEEN CALLED TO WRITE AN INCORRECT NUMBER OF
WORDS FOR ELEMENT ID = *****.
- 3111 *** SYSTEM FATAL MESSAGE 3111. INVALID NUMBER OF PARTITIONS WERE SENT EMGOUT FOR ELEMENT
ID = ***** WITH RESPECT TO DATA BLOCK TYPE = ***.
- 3112 *** USER INFORMATION MESSAGE 3112. ELEMENTS CONGRUENT TO ELEMENT ID = ***** WILL BE
RE-COMPUTED AS THERE IS INSUFFICIENT CORE AT THIS MOMENT TO HOLD DICTIONARY DATA.
- 3113A *** SYSTEM INFORMATION MESSAGE 3113. EMGPR0 PROCESSING **** PRECISION ELEMENTS OF TYPE
***** STARTING WITH ID *****.

DIAGNOSTIC MESSAGES

- 3113B*** SYSTEM WARNING MESSAGE 3113. EMGOLD HAS RECEIVED A CALL FOR ELEMENT ***** WHICH IS OF ELEMENT TYPE ***** AND NOT HANDLED BY EMGOLD. ELEMENT IGNORED.
- 3114 *** SYSTEM FATAL MESSAGE 3114. EMGOLD COMPATIBILITY ROUTINE CAN NOT HANDLE THE QUANTITY OF CONNECTIONS FOR SILS ELEMENT *****.
- 3115 *** USER WARNING MESSAGE 3115. EMGOLD FINDS ELEMENT TYPE ***** PRESENT IN A HEAT FORMULATION AND IS IGNORING SAME.
- 3116 *** SYSTEM FATAL MESSAGE 3116. ELEMENT ID ***** SENDS BAD SIL TO ROUTINE EMG1B.
- 3118 *** USER FATAL MESSAGE 3118. R0D ELEMENT NO. ***** HAS ILLEGAL GEOMETRY OR CONNECTIONS.
- 3119 *** USER FATAL MESSAGE 3119. INSUFFICIENT CORE TO PROCESS R0D ELEMENTS.
- 3120 *** USER WARNING MESSAGE 3120. IMPROPER CONNECTION ON CELAS ELEMENT, *****.
- 3123 *** USER FATAL MESSAGE 3123. PARAMETER NUMBER ***** NOT IN DMAP CALL.
- 3124 *** USER FATAL MESSAGE 3124. PARAMETER NUMBER ***** IS NOT A VARIABLE.
- 3125 *** SYSTEM FATAL MESSAGE 3125. INVALID TABLE NUMBER. *****, IS NO. *****, OF *****, PASSED TO PRETABLE.
- 3128 *** SYSTEM WARNING MESSAGE 3128. **** AND **** ARE EQUIVALENT LABELS. CONSULT BOTH FOR INTERCHANGEABLE XREF.
- 3131 *** USER FATAL MESSAGE 3131. INPUT STIFFNESS AND MASS MATRICES ARE NOT COMPATIBLE.
- The matrices must be the same size to properly perform matrix operations.
- 3199 *** USER WARNING MESSAGE 3199. NON-FATAL MESSAGES MAY HAVE BEEN LOST BY ATTEMPTING TO QUEUE MORE THAN ***** MESSAGES.
- 3300 *** SYSTEM WARNING MESSAGE 3300. INVALID PARAMETER ***** SUPPLIED TO MODULE DIAGONAL, COLUMN SUBSTITUTED.

NASTRAN SYSTEM AND USER MESSAGES

4000 *** USER WARNING MESSAGE 4000, ONE SIDE OF ELEMENT ***** CONNECTING FOUR POINTS IS NOT APPROXIMATELY PLANAR.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers, or incorrect grid point identification numbers.

4001 *** USER FATAL MESSAGE 4001, ELEMENT ***** DOES NOT HAVE CORRECT GEOMETRY.

4002 *** USER FATAL MESSAGE 4002, MODULE SSG1 DETECTS BAD OR REVERSED GEOMETRY FOR ELEMENT ID *****.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers or incorrect grid point identification numbers. Subtetrahedra must have nonzero volume.

4003 *** USER FATAL MESSAGE 4003, AN ILLEGAL VALUE OF -NU- HAS BEEN SPECIFIED UNDER MATERIAL ID ***** FOR ELEMENT ID *****.

Solid WEDGE and HEXAi elements must not have Poisson's Ratio equal to 0.5.

4004 *** USER FATAL MESSAGE 4004, MODULE SMA1 DETECTS BAD OR REVERSED GEOMETRY FOR ELEMENT ID *****.

Check CWEDGE and CHEXAi cards for order of grid point identification numbers, or incorrect grid point identification numbers. Subtetrahedra must have nonzero volume.

4005 *** USER FATAL MESSAGE 4005, AN ILLEGAL VALUE OF -NU- HAS BEEN SPECIFIED UNDER MATERIAL ID ***** FOR ELEMENT ID *****.

Solid TETRA elements must not have Poisson's Ratio equal to 0.5.

DIAGNOSTIC MESSAGES

- 4010 *** USER FATAL MESSAGE 4010, TEMPP3 BULK DATA CARD WITH SETID = ***** AND ELEMENT ID = ***** DOES NOT HAVE ASCENDING VALUES SPECIFIED FOR Z.
- 4011 *** USER FATAL MESSAGE 4011, ELEMENT TEMPERATURE SET ***** CONTAINS MULTIPLE TEMPERATURE DATA SPECIFIED FOR ELEMENT ID *****.
Temperature for element is specified on more than one bulk data card.
- 4012 *** USER FATAL MESSAGE 4012, THERE IS NO ELEMENT, GRID POINT, OR DEFAULT TEMPERATURE DATA FOR TEMPERATURE SET ***** WITH RESPECT TO ELEMENT *****.
- 4013 *** USER FATAL MESSAGE 4013, PROBLEM LIMITATION OF 66 TEMPERATURE SETS HAS BEEN EXCEEDED.
- 4014 *** SYSTEM FATAL MESSAGE 4014, ROUTINE EDTL DETECTS BAD DATA ON TEMPERATURE DATA BLOCK FOR SET ID = *****.
Data block GPTT should be investigated.
- 4015 *** SYSTEM WARNING MESSAGE 4015, ELEMENT THERMAL AND DEFORMATION LOADING NOT COMPUTED FOR ILLEGAL ELEMENT TYPE ***** IN MODULE SSG1.
Only certain elements have algorithms for enforced deformation or thermal loading. This element type will not produce a load. Check DEFORM and TEMPP1, TEMPP2, TEMPP3, and TEMPRB bulk data cards.
- 4016 *** USER FATAL MESSAGE 4016, THERE IS NO TEMPERATURE DATA FOR ELEMENT ***** IN SET *****.
- 4017 *** USER FATAL MESSAGE 4017, THERE IS NO TEMPERATURE DATA FOR ELEMENT ***** IN SET *****.
- 4018 *** USER FATAL MESSAGE 4018, A SINGULAR MATERIAL MATRIX -D- FOR ELEMENT ***** HAS BEEN DETECTED BY ROUTINE SSGKHI WHILE TRYING TO COMPUTE THERMAL LOADS WITH TEMPP2 CARD DATA.
The element bending load - curvature relation is at fault and cannot be inverted.
- 4019 *** SYSTEM FATAL MESSAGE 4019, SDR2E DETECTS INVALID TEMPERATURE DATA FOR *****.
Data block table GPTT should be investigated.
- 4020 *** SYSTEM FATAL MESSAGE 4020, TA1A HAS PICKED UP TEMPERATURE SET ***** AND NOT THE REQUESTED SET *****.
The requested temperature set Id. for temperature dependent material properties can not be found in data block GPTT.
- 4021 *** SYSTEM FATAL MESSAGE 4021, TA1B HAS PICKED UP TEMPERATURE SET ***** AND NOT THE REQUESTED SET *****.
The requested temperature set Id. for temperature dependent material properties can not be found in data block GPTT.
- 4022 *** USER FATAL MESSAGE 4022, TA1B FINDS NO ELEMENT, GRIDPOINT, OR DEFAULT TEMPERATURE DATA FOR ELEMENT ID = *****.

NASTRAN SYSTEM AND USER MESSAGES

4023 *** USER FATAL MESSAGE 4023, TAIA FINDS NO ELEMENT, GRIDPOINT, OR DEFAULT TEMPERATURE DATA FOR ELEMENT ID = *****.

4024 *** USER FATAL MESSAGE 4024, NO CYJOIN CARDS WERE SUPPLIED.

4025 *** USER FATAL MESSAGE 4025, NO SIDE 1 DATA FOUND.

4026 *** USER FATAL MESSAGE 4026, TOO MANY SIDE 1 CARDS.

4027 *** USER FATAL MESSAGE 4027, NUMBER OF ENTRIES IN SIDE 1 NOT EQUAL TO NUMBER IN SIDE 2.

4028 *** USER FATAL MESSAGE 4028, THE CODE FOR GRID POINT, ***** DOES NOT MATCH THE CODE FOR GRID POINT *****.

A GRID point on SIDE 1 must be connected to a GRID point on SIDE 2 and a SCALAR point on SIDE 1 must be connected to a SCALAR point on SIDE 2.

4029 *** USER FATAL MESSAGE 4029, GRID POINT, ***** APPEARS IN BOTH SIDE LISTS.

4030 *** USER WARNING MESSAGE 4030, COMPONENT *** OF GRID POINTS, ***** AND ***** CANNOT BE CONNECTED.

4031 *** USER FATAL MESSAGE 4031, INSUFFICIENT CORE = **** TO READ DATA ON AXIF CARD.

4032 *** USER WARNING MESSAGE 4032, NO COMPONENTS OF GRID POINTS, ***** AND ***** WERE CONNECTED.

4033 *** USER FATAL MESSAGE 4033, COORDINATE SYSTEM ID = **** AS SPECIFIED ON AXIF CARD IS NOT PRESENT AMONG ANY OF CORDIC, CORDIS, CORD2C, OR CORD2S CARD TYPES.

Cylindrical type assumed for continuing data check.

4034 *** USER FATAL MESSAGE 4034, INSUFFICIENT CORE = **** TO HOLD GRIDB CARD IMAGES.

4035 *** USER FATAL MESSAGE 4035, THE FLUID DENSITY HAS NOT BEEN SPECIFIED ON A BDYLIST CARD AND THERE IS NO DEFAULT FLUID DENSITY SPECIFIED ON THE AXIF CARD.

4036 *** USER FATAL MESSAGE 4036, INSUFFICIENT CORE TO BUILD BOUNDARY LIST TABLE.

4037 *** USER FATAL MESSAGE 4037, GRID POINT ***** IS LISTED MORE THAN ONCE.

4038 *** USER FATAL MESSAGE 4038, RINGFL CARD HAS ID = **** WHICH HAS BEEN USED.

An identification number of a RINGFL card is not unique.

4039 *** USER FATAL MESSAGE 4039, NO COORDINATE SYSTEM DEFINED FOR GRID POINT *****.

DIAGNOSTIC MESSAGES

4040 *** USER FATAL MESSAGE 4040, ID = **** APPEARS ON A BDYLIST CARD, BUT NO RINGFL CARD IS PRESENT WITH THE SAME ID.

4041 *** USER FATAL MESSAGE 4041, ID = **** IS OUT OF PERMISSABLE RANGE OF 1 to 499999.

The identification number of a RINGFL is too large to be processed.

4042 *** USER FATAL MESSAGE 4042, COORDINATE SYSTEM IS CYLINDRICAL BUT RINGFL CARD ID = **** HAS A NONZERO X2 VALUE.

The azimuthal angle of a RINGFL point must be zero.

4043 *** USER FATAL MESSAGE 4043, COORDINATE SYSTEM IS SPHERICAL BUT RINGFL CARD ID = **** HAS A NONZERO X3 VALUE.

The azimuthal angle of a RINGFL point must be zero.

4044 *** USER FATAL MESSAGE 4044, RINGFL CARD ID = **** HAS SPECIFIED A ZERO RADIAL LOCATION.

4045 *** USER FATAL MESSAGE 4045, THE BOUNDARY LIST ENTRY FOR ID = **** HAS A ZERO CROSS-SECTIONAL LENGTH.

A hydroelastic boundary can not be defined between two RINGFL points having the same location. Check BDYLIST and RINGFL.

4047 *** USER FATAL MESSAGE 4047, INSUFFICIENT CORE TO HOLD RINGFL IMAGES.

4048 *** USER FATAL MESSAGE 4048, THE FLUID DENSITY HAS NOT BEEN SPECIFIED ON A FSLIST CARD AND THERE IS NO DEFAULT FLUID DENSITY SPECIFIED ON THE AXIF CARD.

NASTRAN SYSTEM AND USER MESSAGES

- 4049 *** USER FATAL MESSAGE 4049, INSUFFICIENT CORE TO BUILD FREE SURFACE LIST TABLE.
- 4050 *** USER FATAL MESSAGE 4050, FSLIST CARD HAS INSUFFICIENT IDF DATA, OR FSLIST DATA MISSING.
A referenced RINGFL point doesn't exist or the FSLIST card is in error. At least two points must be defined.
- 4051 *** USER FATAL MESSAGE 4051, AN MPC CARD HAS A SET ID SPECIFIED = 102. SET 102 IS ILLEGAL WHEN FLUID DATA IS PRESENT
This set identification number is reserved for internal use in hydroelastic problems.
- 4052 *** USER FATAL MESSAGE 4052, IDF = **** ON A FREEPT CARD DOES NOT APPEAR ON ANY FSLIST CARD.
A referenced RINGFL point must also appear on a FSLIST card.
- 4053 *** USER FATAL MESSAGE 4053, INSUFFICIENT CORE TO PERFORM OPERATIONS REQUIRED AS A RESULT OF FREEPT OR PRESPT DATA CARDS.
- 4054 *** USER FATAL MESSAGE 4054, SET ID = 102 MAY NOT BE USED FOR SPC CARDS WHEN USING THE HYDROELASTIC-FLUID ELEMENTS.
This set identification number is reserved for internal use in hydroelastic problems.
- 4055 *** USER FATAL MESSAGE 4055, SET ID = 102 MAY NOT BE USED FOR SPC CARDS WHEN USING THE HYDROELASTIC-FLUID ELEMENTS.
This set identification number is reserved for internal use in hydroelastic problems.
- 4056 *** USER FATAL MESSAGE 4056, RECORD ID **** IS OUT OF SYNC ON DATA BLOCK NUMBER **** AN IFP4 SYSTEM ERROR.
The record identification numbers are the values of LOCATE record ID. The data block numbers are the GIN0 file numbers. Error implies that IFP4 is possibly operating on the wrong data block. This system error should not occur. Message comes from IFP4B.
- 4057 *** USER FATAL MESSAGE 4057, GRIDB CARD WITH ID = **** HAS A REFERENCE IDF = **** WHICH DOES NOT APPEAR IN A BOUNDARY LIST.
- 4058 *** USER FATAL MESSAGE 4058, THE FLUID DENSITY HAS NOT BEEN SPECIFIED ON A CFLUID CARD WITH ID = *** AND THERE IS NO DEFAULT ON THE AXIF CARD.
- 4059 *** USER FATAL MESSAGE 4059, THE FLUID BULK MODULUS HAS NOT BEEN SPECIFIED ON A CFLUID CARD WITH ID = **** AND THERE IS NO DEFAULT ON THE AXIF CARD.
- 4060 *** SYSTEM FATAL MESSAGE 4060, COORDINATE SYSTEM = **** CAN NOT BE FOUND IN CSTM DATA.
Data blocks MATPOOL or CSTM have been changed illegally.
- 4061 *** SYSTEM FATAL MESSAGE 4061, CONNECTED FLUID POINT ID = **** IS MISSING BGPDT DATA.
Data blocks MATPOOL or BGPDT have been changed illegally.

DIAGNOSTIC MESSAGES

4062 *** USER FATAL MESSAGE 4062, DMIG BULK DATA CARD SPECIFIES DATA BLOCK **** WHICH ALSO APPEARS ON A DMIAX CARD.

One direct input matrix may not be specified by both types of bulk data cards.

4063 *** USER FATAL MESSAGE 4063, ILLEGAL VALUE **** FOR PARAMETER CTYPE.

4064 *** USER FATAL MESSAGE 4064, ILLEGAL VALUES ***** FOR PARAMETERS NSEGS, KMAX.

4065 *** USER FATAL MESSAGE 4065, ILLEGAL VALUE ***** FOR PARAMETER NL0AD.

4066 *** USER FATAL MESSAGE 4066, SECOND OUTPUT DATA BLOCK MUST NOT BE PURGED.

The transformation matrix between physical and symmetric components does not exist. Ensure the number of Case Control subcases is specified correctly and that the component loads are properly ordered.

4067 *** USER FATAL MESSAGE 4067, VIN HAS ***** C0LS, GCYC HAS ***** R0WS.

Follows message 4064 indicating the illegal values for NSEGS and KMAX.

4081 *** USER FATAL MESSAGE 4081, AXSL0T DATA CARD IS NOT PRESENT OR IS INCORRECT.

Acoustic analysis data is present and this data card is necessary.

4082 *** USER FATAL MESSAGE 4082, INSUFFICIENT CORE TO HOLD ALL GRIDS CARD IMAGES.

Executive Module IFP5 must hold this data in core. Increase core size or decrease amount of data.

4083 *** USER FATAL MESSAGE 4083, INSUFFICIENT CORE TO HOLD ALL GRIDF CARD IMAGES.

Executive Module IFP5 must hold this data in core. Increase core size or decrease amount of data.

4084 *** USER FATAL MESSAGE 4084, INSUFFICIENT CORE TO HOLD ALL GRIDF CARD IMAGES BEING CREATED INTERNALLY DUE TO GRIDS CARDS SPECIFYING AN IDF.

Executive Module IFP5 is creating GRIDF cards from GRIDS cards. Increase core size.

4085 *** USER FATAL MESSAGE 4085, INSUFFICIENT CORE TO CONSTRUCT ENTIRE BOUNDARY TABLE FOR SLBDY DATA CARDS.

Executive Module IFP5 requires five words of core for each entry in the SLBDY cards.

4086 *** USER FATAL MESSAGE 4086, CELAS2 DATA CARD HAS ID = XXX WHICH IS GREATER THAN 10000000, AND 10000000 IS THE LIMIT FOR CELAS2 ID WITH ACOUSTIC ANALYSIS DATA CARDS PRESENT.

Executive Module IFP5 is generating CELAS2 images and a possible conflict of ID numbers exists.

4087 *** USER FATAL MESSAGE 4087, SLBDY ID = XXX DOES NOT APPEAR ON ANY GRIDS DATA CARD.

The SLBDY data card has a point listed which does not exist in the data.

NASTRAN SYSTEM AND USER MESSAGES

4088 *** USER FATAL MESSAGE 4088, ONE OR MORE OF THE FOLLOWING ID-S NOT EQUAL TO -1 HAVE INCORRECT OR NO GEOMETRY DATA. ID = XXX, ID = XXX, ID = XXX.

The listed GRIDS points may have a bad radius or a slot width greater than geometrically possible.

4089 *** USER FATAL MESSAGE 4089, RHO AS SPECIFIED ON SLBDY OR AXSLDT DATA CARD IS 0.0 FOR ID = XXX.

A value of density is required to formulate the slot boundary matrix terms.

4090 *** USER FATAL MESSAGE 4090, ONE OF THE FOLLOWING NON-ZERO IDENTIFICATION NUMBERS APPEARS ON SOME COMBINATION GRID, GRIDS, OR GRIDF BULK DATA CARDS. ID = XXX, ID = XXX, ID = XXX.

All GRID, SPPOINT, EPOINT, GRIDS, and GRIDF data cards should have unique identification numbers.

DIAGNOSTIC MESSAGES

- 4091 *** USER FATAL MESSAGE 4091, BAD GEOMETRY OR ZERO COEFFICIENT FOR SLOT ELEMENT NUMBER XXX.
The listed CSLØT3 or CØSØT4 element has its connected points defining zero area or its density equal to zero.
- 4100 *** SYSTEM FATAL MESSAGE 4100, ØUTPUT3 UNABLE TO ØPEN DATA BLØCK *****.
- 4101 *** SYSTEM FATAL MESSAGE 4101, ØUTPUT3 UNABLE TO FIND NAME FOR DATA BLØCK *****.
- 4102 *** SYSTEM FATAL MESSAGE 4102, ØUTPUT3 EOF.
- 4103 *** USER INFORMATION MESSAGE 4103, ØUTPUT3 HAS PUNCHED MATRIX DATA BLØCK ***** ØNTØ DMI CARDS.
- 4104 *** USER FATAL MESSAGE 4104, ATTEMPT TO PUNCH MORE THAN 9999 DMI CARDS FOR A SINGLE MATRIX.
- 4105 *** USER INFORMATION MESSAGE 4105, DATA BLØCK ***** RETRIEVED FROM USER TAPE ****
NAME OF DATA BLØCK WHEN PLACED ON USER TAPE WAS *****.
- 4106 *** SYSTEM FATAL MESSAGE 4106, MØDULE INPUTT1 - SHØRT REC.
- 4107 *** SYSTEM FATAL MESSAGE 4107, SUBRØUTINE INPTT1 UNABLE TO ØPEN NASTRAN FILE ****.
- 4108 *** SYSTEM FATAL MESSAGE 4108, SUBRØUTINE INPTT1 UNABLE TO ØPEN ØUTPUT DATA BLØCK ****.
- 4109 *** SYSTEM FATAL MESSAGE 4109, UNEXPECTED EOF IN SUBRØUTINE INPTT1.
- 4110 *** SYSTEM FATAL MESSAGE 4110, UNEXPECTED EØR IN SUBRØUTINE INPTT1.
- 4111 *** USER FATAL MESSAGE 4111, MØDULE INPUTT1 IS UNABLE TO SKIP FORWARD ***** DATA BLØCKS
ON PERMANENT NASTRAN FILE **** NUMBER OF DATA BLØCKS SKIPPED = *****.
- 4112 *** USER FATAL MESSAGE 4112, MØDULE INPUTT1 - ILLEGAL VALUE FOR SECØND PARAMETER =
*****.
- 4113 *** USER FATAL MESSAGE 4113, MØDULE INPUTT1 - ILLEGAL VALUE FOR FIRST PARAMETER =
*****.
- 4114 *** USER INFORMATION MESSAGE 4114, DATA BLØCK ***** WRITTEN ON NASTRAN FILE ****,
TRL = *****.
- 4115 *** SYSTEM FATAL MESSAGE 4115, MØDULE ØUTPUT1 - SHØRT REC.
- 4116 *** SYSTEM FATAL MESSAGE 4116, SUBRØUTINE ØUTPT1 UNABLE TO ØPEN INPUT DATA BLØCK ****.
- 4117 *** SYSTEM FATAL MESSAGE 4117, SUBRØUTINE ØUTPT1 UNABLE TO ØPEN NASTRAN FILE ****.

NASTRAN SYSTEM AND USER MESSAGES

4118 *** USER FATAL MESSAGE 4118, ***** MODULE OUTPUT1 IS UNABLE TO SKIP FORWARD *****
DATA BLOCKS ON PERMANENT NASTRAN FILE ****. **** NUMBER OF DATA BLOCKS SKIPPED = *****.

4119 *** USER FATAL MESSAGE 4119, MODULE OUTPUT1 - ILLEGAL VALUE FOR SECOND PARAMETER =
*****.

4120 *** USER FATAL MESSAGE 4120, MODULE OUTPUT1 - ILLEGAL VALUE FOR FIRST PARAMETER =

4121 *** USER FATAL MESSAGE 4121, ONLY ONE (1) AXIF CARD ALLOWED IN BULK DATA.

4122 *** USER FATAL MESSAGE 4122, AXIF CARD REQUIRED.

4123 *** USER FATAL MESSAGE 4123, ONLY ONE (1) FLSYM CARD ALLOWED IN BULK DATA.

4124 *** USER WARNING MESSAGE 4124, THE SPCADD OR MPCADD UNION CONSISTS OF A SINGLE SET.

4125 *** USER FATAL MESSAGE 4125, MAXIMUM ALLOWABLE HARMONIC ID IS 99. DATA CONTAINS MAXIMUM =
****.

4126 *** USER FATAL MESSAGE 4126, BAD DATA OR FORMAT OR NONUNIQUE NAME, DMIAX ****.

4127 *** USER FATAL MESSAGE 4127, USER TAPE **** NOT SET UP.

4128 *** USER FATAL MESSAGE 4128, MODULE OUTPUT1 - END-OF-FILE ENCOUNTERED WHILE ATTEMPTING TO
READ TAPE ID CODE ON USER TAPE ****.

4129 *** USER FATAL MESSAGE 4129, MODULE OUTPUT1 - END-OF-RECORD ENCOUNTERED WHILE ATTEMPTING TO
READ TAPE ID CODE ON USER TAPE ****.

4130 *** USER FATAL MESSAGE 4130, MODULE OUTPUT1 - ILLEGAL TAPE CODE HEADER = *****.

4131 *** USER WARNING MESSAGE 4131, USER TAPE ID CODE - ***** - DOES NOT MATCH THIRD OUTPUT1
DMAP PARAMETER - *****.

4132 *** USER FATAL MESSAGE 4132, MODULE INPUT1 - END-OF-FILE ENCOUNTERED WHILE ATTEMPTING TO
READ TAPE ID CODE ON USER TAPE ****.

4133 *** USER FATAL MESSAGE 4133, MODULE INPUT1 - END-OF-RECORD ENCOUNTERED WHILE ATTEMPTING TO
READ TAPE ID CODE ON USER TAPE ****.

4134 *** USER FATAL MESSAGE 4134, MODULE INPUT1 - ILLEGAL TAPE CODE HEADER = *****.

4135 *** USER WARNING MESSAGE 4135, USER TAPE ID CODE - ***** DOES NOT MATCH THIRD INPUT1 DMAP
PARAMETER - ***** -.

DIAGNOSTIC MESSAGES

- 4136 *** USER FATAL MESSAGE 4136, USER TAPE ID CODE - ***** - DOES NOT MATCH THIRD INPUTT1 DMAP PARAMETER - ***** -.
- 4137 *** USER WARNING MESSAGE 4137, ALL OUTPUT DATA BLOCKS FOR INPUTT1 ARE PURGED.
- 4138 *** USER WARNING MESSAGE 4138, DATA BLOCK ***** (DATA BLOCK COUNT = ***** HAS PREVIOUSLY BEEN RETRIEVED FROM USER TAPE ***** AND WILL BE IGNORED.
- 4139 *** USER INFORMATION MESSAGE 4139, DATA BLOCK ***** RETRIEVED FROM USER TAPE ***** (DATA BLOCK COUNT = *****)
- 4140 *** USER WARNING MESSAGE 4140, SECONDARY VERSION OF DATA BLOCK HAS REPLACED EARLIER ONE.
- 4141 *** USER WARNING MESSAGE 4141, ONE OR MORE DATA BLOCKS NOT FOUND ON USER TAPE.
- 4142 *** USER FATAL MESSAGE 4142, ONE OR MORE DATA BLOCKS NOT FOUND ON USER TAPE.
- 5000 *** USER FATAL MESSAGE 5000, NEG. OR ZERO RADIUS DETECTED FOR CFLUID2 ELEMENT. ELEMENT NO. *****.
- 5001 *** USER FATAL MESSAGE 5001, NEG. OR ZERO RADIUS DETECTED FOR CFLUID3 OR CFLUID4 ELEMENT. ELEMENT NO. *****.
- 5002 *** USER FATAL MESSAGE 5002, INTERIOR ANGLE GREATER THAN OR EQUAL TO 180 DEGREES. CFLUID4 ELEMENT NO. *****.
- 5011 *** USER FATAL MESSAGE 5011, FIRST PARAMETER ***** NE TRAILER RECORD PARAMETER *****.
- 5012 *** USER FATAL MESSAGE 5012, ENTRY ***** OF SIL TABLE INCOMPATIBLE WITH NEXT ENTRY.

NASTRAN SYSTEM AND USER MESSAGES

- 6001 *** USER FATAL MESSAGE 6001, SUBSTRUCTURE DATA IS REQUIRED WITH THIS APPROACH.
The program expects a SUBSTRUCTURE card following the CEND card if APP DISP, SUBS was used.
- 6002 *** USER WARNING MESSAGE 6002, INCORRECT PHASE DATA
The second word on the substructure command should be PHASEi, i = 1, 2, 3. The default is 2.
- 6003 *** USER FATAL MESSAGE 6003. ILLEGAL COMMAND OR OPTION DEFINED ON PREVIOUS CARD.
The program does not recognize the previous card. If any "subcommand" cards follow this error, they may produce this message until a legitimate command card is encountered.
- 6004 *** USER WARNING MESSAGE 6004, NO PREFIX DEFINED AFTER EQUIVALENCE COMMAND.
A non-basic substructure requires a prefix for the equivalent lower level basic substructures. A basic substructure does not require the prefix.
- 6005 *** USER FATAL MESSAGE 6005, ILLEGAL OR MISSING INPUT DATA GIVEN FOR PREVIOUS COMMAND.
Either the basic command data is insufficient or mandatory additional subcommands are missing.
- 6006 *** USER FATAL MESSAGE 6006, DMAP ALTERS INTERFERE WITH SUBSTRUCTURE ALTERS.
The DMAP instruction numbers on the user ALTER data card overlaps or conflicts with the sections automatically modified. Use DIAG 23 to print the DMAP ALTER package or see Section 5.5.
- 6007 *** SYSTEM FATAL MESSAGE 6007, IMPROPER FILE SETUP FOR ****.
An external I/O operation has been defined but the file is missing or the card is improper.
- 6008 *** USER FATAL MESSAGE 6008, ILLEGAL INPUT ON THE PREVIOUS COMMAND. MISSING FILE NAME FOR I/O OPERATION.
- 6009 *** SYSTEM FATAL MESSAGE 6009, UNRECOVERABLE ERROR CONDITIONS IN SUBROUTINE ASDMAP.
- 6010 *** SYSTEM FATAL MESSAGE 6010, ILLEGAL VARIABLE TO BE SET IN DMAP STATEMENT, (N).
The system has been encountered illegal type of word to be inserted in a DMAP sequence. Could possibly occur if a floating point number were used instead of an integer on an input card.
- 6011 *** USER FATAL MESSAGE 6011, MISSING PASSWORD OR SØF DATA.
The SØF and PASSWORD cards are mandatory. At least one SØF file (SØF(1) must be defined.
- 6012 *** SYSTEM FATAL MESSAGE 6012, FILE=**** IS PURGED OR NULL AND IS REQUIRED IN PHASE1 SUBSTRUCTURE ANALYSIS.
- 6013 *** USER FATAL MESSAGE 6013, ILLEGAL TYPE OF POINT DEFINED FOR SUBSTRUCTURE ANALYSIS. POINT NUMBER=*****.

DIAGNOSTIC MESSAGES

6014 *** USER FATAL MESSAGE 6014, INSUFFICIENT CORE TO LOAD TABLES IN MODULE SUBPH1, CORE=*****.

6015 *** USER FATAL MESSAGE 6015, TOO MANY CHARACTERS TO BE INSERTED IN A DMAP LINE. N=***,

A BCD word has been defined with too many characters to fit the space in the DMAP.
(Usual limit = 8.) Message could also occur if block data subprogram ASDBD has an error.

6016 *** USER FATAL MESSAGE 6016, TOO MANY DIGITS TO BE INSERTED IN DMAP VALUE=***.

An integer is limited to eight digits.

6022 *** USER FATAL MESSAGE 6022, SUBSTRUCTURE ***, GRID POINT ***, COMPONENT ***, REFERENCED ON
*** CARD DOES NOT EXIST IN SOLUTION STRUCTURE ***.

6050 *** USER WARNING MESSAGE 6050, REQUESTED PLOT SET NO. ***** HAS NOT BEEN DEFINED.

NASTRAN SYSTEM AND USER MESSAGES

- 6101 *** SYSTEM FATAL MESSAGE 6101, REQUESTED SØF ITEM DØES NØT EXIST. ITEM ***, SUBSTRUCTURE ***.
Either the item has never been created or it only pseudo exists from a prior dry run.
- 6102 *** SYSTEM FATAL MESSAGE 6102, REQUESTED SUBSTRUCTURE DØES NØT EXIST. ITEM ***, SUBSTRUCTURE ***.
- 6103 *** SYSTEM FATAL MESSAGE 6103, REQUESTED SØF ITEM HAS INVALID NAME. ITEM ***, SUBSTRUCTURE ***.
Item name is illegal.
- 6104 *** USER FATAL MESSAGE 6104, ATTEMPT TØ CREATE DUPLICATE SUBSTRUCTURE NAME ***.
- 6105 *** USER FATAL MESSAGE 6105, ATTEMPT TØ RE-USE SUBSTRUCTURE *** IN A REDUCE ØR CØMBINE ØPERATION. USE EQUIV SUBSTRUCTURE CØMMAND.
A single substructure may be reduced or combined repeatedly only if it is given equivalent names with the EQUIV substructure command.
- 6106 *** SYSTEM FATAL MESSAGE 6106, UNEXPECTED END ØF GRØUP ENCØUNTERED WHILE READING ITEM *** SUBSTRUCTURE ***.
- 6107 *** SYSTEM FATAL MESSAGE 6107, UNEXPECTED END ØF ITEM ENCØUNTERED WHILE READING ITEM *** SUBSTRUCTURE ***.
- 6108 *** SYSTEM FATAL MESSAGE 6108, INSUFFICIENT SPACE ØN SØF FØR ITEM ***, SUBSTRUCTURE ***.
- 6201 *** SYSTEM INFOØRMATION MESSAGE 6201, *** FILES HAVE BEEN ALLØCATED TØ THE SØF WHERE
SIZE ØF FILE 1 = *** BLØCKS
:
SIZE ØF FILE *** = *** BLØCKS
AND WHERE A BLØCK CØNTAINS *** WØRDS
- 6202 *** USER FATAL MESSAGE 6202, THE REQUESTED NUMBER ØF FILES IS NØN-PØSITIVE.
- 6204 *** USER FATAL MESSAGE 6204, SUBRØUTINE *** - THE SUBRØUTINE SØFØPN SHØULD BE CALLED PRIØR TØ ANY ØF THE SØF UTILITY SUBRØUTINES.
- 6205 *** USER FATAL MESSAGE 6205, SUBRØUTINE *** - THE BUFFER SIZE HAS BEEN MØDIFIED.
- 6206 *** USER FATAL MESSAGE 6206, SUBRØUTINE *** - WRØNG PASSWØRD ØN SØF FILE ***.
- 6207 *** USER FATAL MESSAGE 6207, SUBRØUTINE *** - THE SØF FILE *** IS ØUT ØF SEQUENCE.
- 6208 *** USER FATAL MESSAGE 6208, SUBRØUTINE *** - THE SIZE OF THE SØF FILE *** HAS BEEN MØDIFIED.

DIAGNOSTIC MESSAGES

- 6209 *** USER FATAL MESSAGE 6209, SUBROUTINE *** - THE NEW SIZE OF FILE *** IS TOO SMALL.
- 6211 *** USER WARNING MESSAGE 6211, MODULE *** - ITEM *** OF SUBSTRUCTURE *** HAS ALREADY BEEN WRITTEN.
- 6212 *** USER WARNING MESSAGE 6212, MODULE *** - THE SUBSTRUCTURE *** DOES NOT EXIST.
- 6213 *** USER WARNING MESSAGE 6213, MODULE *** - *** IS AN ILLEGAL ITEM NAME.
- 6215 *** USER WARNING MESSAGE 6215, MODULE *** - ITEM *** OF SUBSTRUCTURE *** PSEUDO-EXISTS ONLY.
- 6216 *** USER WARNING MESSAGE 6216, MODULE *** - ITEM *** OF SUBSTRUCTURE *** DOES NOT EXIST.
- 6217 *** USER WARNING MESSAGE 6217, MODULE *** - *** IS AN ILLEGAL PARAMETER NAME.
- 6218 *** USER WARNING MESSAGE 6218, MODULE *** - THE SUBSTRUCTURE *** CANNOT BE DESTROYED BECAUSE IT IS AN IMAGE SUBSTRUCTURE.
- 6219 *** USER WARNING MESSAGE 6219, MODULE *** RUN EQUALS DRY OR STEP, AND, SUBSTRUCTURE *** OR ONE OF THE NEW NAMES ALREADY EXISTS.
- 6220 *** USER WARNING MESSAGE 6220, MODULE *** - RUN EQUALS GO, AND, SUBSTRUCTURE *** OR ONE OF THE NEW NAMES DOES NOT EXIST.
- 6222 *** USER FATAL MESSAGE 6222 - ATTEMPT TO CALL SDFOPN MORE THAN ONCE WITHOUT CALLING SDFCLS.
- 6223 *** USER FATAL MESSAGE 6223 - SUBROUTINE *** - THERE ARE NO MORE FREE BLOCKS AVAILABLE ON THE SDF.
- 6224 *** SYSTEM FATAL MESSAGE 6224, SDF UTILITY SUBROUTINE ***.
Text follows the message to describe the error.
- 6225 *** SYSTEM FATAL MESSAGE 6225, BLOCK NUMBER *** OUT OF RANGE OF SDF FILES.
This can be caused only by a logic error in one of the SDF subroutines.
- 6226 *** SYSTEM WARNING MESSAGE 6226, SUBROUTINE SDFIO - HIBLK PARAMETER FOR SDFIO DID NOT CONFORM TO PHYSICAL FILE. PARAMETER VALUE HAS BEEN CHANGED FROM *** TO ***.
This can be caused when the previous run using the SDF terminated abnormally. (CDC only.)
- 6227 *** SYSTEM FATAL MESSAGE 6227, AN ATTEMPT HAS BEEN MADE TO OPERATE ON THE MATRIX ITEM *** OF SUBSTRUCTURE *** USING SFETCH.

NASTRAN SYSTEM AND USER MESSAGES

6228 *** USER INFORMATION MESSAGE 6228, SUBSTRUCTURE *** IS ALREADY EQUIVALENT TO SUBSTRUCTURE ***.
ONLY ITEMS NOT PREVIOUSLY EXISTING FOR *** HAVE BEEN MADE EQUIVALENT.

6229 *** USER INFORMATION MESSAGE 6229, SUBSTRUCTURE *** HAS BEEN RENAMED TO ***.

6230 *** USER WARNING MESSAGE 6230, SUBSTRUCTURE *** HAS NOT BEEN RENAMED BECAUSE *** ALREADY
EXISTS ON THE SDF.

6231 *** USER WARNING MESSAGE 6231, INSUFFICIENT CORE AVAILABLE OR ILLEGAL ITEM FORMAT REQUIRES
AN UNFORMATTED DUMP TO BE PERFORMED FOR ITEM *** OF SUBSTRUCTURE ***.

DIAGNOSTIC MESSAGES

- 6301 *** SYSTEM FATAL MESSAGE 6301, DATA MISSING IN G0 MODE FOR SUBSTRUCTURE ***, ITEM ***.
Item was created in dry run mode and has no real data.
- 6302 *** SYSTEM FATAL MESSAGE 6302, *** IS ILLEGAL MATRIX TYPE FOR MODULE C0MB2.
- 6303 *** SYSTEM FATAL MESSAGE 6303, H0RG TRANSFORMATION MATRIX FOR SUBSTRUCTURE *** CANNOT BE FOUND ON S0F.
- 6304 *** SYSTEM FATAL MESSAGE 6304, MODULE C0MB2 INPUT MATRIX NUMBER *** FOR SUBSTRUCTURE *** HAS INCOMPATIBLE DIMENSIONS.
Matrix dimensions conflict with those of its H or G transformation matrix.
- 6305 *** SYSTEM WARNING MESSAGE 6305, RECORD NUMBER *** OF CASESS IS NOT A RECOVER RECORD. IT IS A *** RECORD.
The step parameter for module RC0VR is incorrect. It should be the CASESS record number of a recover record.
- 6306 *** USER WARNING MESSAGE 6306, ATTEMPT TO RECOVER DISPLACEMENTS FOR NON-EXISTANT SUBSTRUCTURE ***.
- 6307 *** USER WARNING MESSAGE 6307, WHILE ATTEMPTING TO RECOVER DISPLACEMENTS FOR SUBSTRUCTURE ***, THE DISPLACEMENTS FOR SUBSTRUCTURE *** WERE FOUND TO EXIST IN DRY RUN FORM ONLY.
Before you can recover displacements of any substructure, you must first perform an actual solution. See RUN substructure command.
- 6308 *** USER WARNING MESSAGE 6308, NO SOLUTION AVAILABLE FROM WHICH DISPLACEMENTS FOR SUBSTRUCTURE *** CAN BE RECOVERED. HIGHEST LEVEL SUBSTRUCTURE FOUND WAS ***.
Solve the highest level substructure found or combine it to an even higher level and solve.
- 6309 *** SYSTEM FATAL MESSAGE 6309, INSUFFICIENT TIME REMAINING TO RECOVER DISPLACEMENTS OF SUBSTRUCTURE *** FROM THOSE OF SUBSTRUCTURE ***. (PROCESSING USER RECOVER REQUEST FOR SUBSTRUCTURE ***)
- 6310 *** SYSTEM WARNING MESSAGE 6310, INSUFFICIENT SPACE ON S0F TO RECOVER DISPLACEMENTS OF SUBSTRUCTURE *** FROM THOSE OF SUBSTRUCTURE *** WHILE PROCESSING USER RECOVER REQUEST FOR SUBSTRUCTURE ***.
Use the S0F substructure command and increase the size of the S0F and/or add more S0F units. Alternately, use EDIT to remove unwanted data.
- 6311 *** SYSTEM WARNING MESSAGE 6311, SDC0MP DECOMPOSITION FAILED ON K00 MATRIX FOR SUBSTRUCTURE ***.
- 6312 *** USER INFORMATION MESSAGE 6312, LEVEL *** DISPLACEMENTS FOR SUBSTRUCTURE *** HAVE BEEN RECOVERED AND SAVED ON S0F.
- 6313 *** SYSTEM WARNING MESSAGE 6313, INSUFFICIENT CORE FOR RC0VR MODULE WHILE TRYING TO PROCESS PRINTOUT DATA BLOCKS FOR SUBSTRUCTURE ***.
- 6314 *** SYSTEM WARNING MESSAGE 6314, OUTPUT REQUEST CANNOT BE HONORED. RC0VR MODULE OUTPUT DATA BLOCK *** IS PURGED.

NASTRAN SYSTEM AND USER MESSAGES

- 6315 *** USER WARNING MESSAGE 6315, RCØVR MØDULE IS UNABLE TØ FIND SUBSTRUCTURE *** AMØNG THØSE ØN EQSS. LØAD SET *** FØR THAT SUBSTRUCTURE WILL BE IGNØRED IN CREATING THE SØLN ITEM FØR FINAL SØLUTION STRUCTURE ***.
- 6316 *** USER WARNING MESSAGE 6316, RCØVR MØDULE IS UNABLE TØ FIND LØAD SET *** FØR SUBSTRUCTURE *** AMØNG THØSE ØN LØDS. IT WILL BE IGNØRED IN CREATING THE SØLN ITEMS FØR FINAL SØLUTION STRUCTURE ***.
- 6317 *** SYSTEM WARNING MESSAGE 6317, RECØVER ØF DISPLACEMENTS FØR SUBSTRUCTURE *** ABØRTED.
- 6318 *** SYSTEM WARNING MESSAGE 6318, ØUTPUT REQUEST FØR REACTION FØRCES IGNØRED.
- 6319 *** SYSTEM WARNING MESSAGE 6319, DISPLACEMENT MATRIX FØR SUBSTRUCTURE *** MISSING. DISPLACEMENT ØUTPUT REQUESTS CANNØT BE HØNØRED AND SPCFØRCE ØUTPUT REQUESTS CANNØT BE HØNØRED UNLESS THE REACTIONØS HAVE BEEN PREVIOUSLY CØMPUTED.
- 6320 *** SYSTEM WARNING MESSAGE 6320, LØADC DATA MISSING FØR SUBSTRUCTURE ***, EXTERNAL STATIC LØAD SET ***.
No LØADC bulk data cards can be found on GEØM4 or GEØM4 is purged.
- 6321 *** USER INFØRMATION MESSAGE 6321, SUBSTRUCTURE PHASE 3 RECØVER FØR FINAL SØLUTION STRUCTURE *** AND BASIC SUBSTRUCTURE ***.
- 6322 *** SYSTEM FATAL MESSAGE 6322, SØLN ITEM HAS INCØRRECT RIGID FØRMAT NUMBER. PHASE 2 RIGID FØRMAT WAS *** AND PHASE 3 IS ***.
The Rigid Format of Phase 3 must be the same as that used in Phase 2 to obtain the solution.
- 6323 *** USER WARNING MESSAGE 6323, NØ EIGENVALUES FØR THIS SØLUTION.
- 6324 *** USER FATAL MESSAGE 6324, PHASE 3 RECØVER ATTEMPTED FØR NØN-BASIC SUBSTRUCTURE ***.
Substructure Phase 3 can be executed only for basic substructures.
- 6325 *** USER WARNING MESSAGE 6325, SUBSTRUCTURE PHASE 1, BASIC SUBSTRUCTURE *** ALREADY EXISTS ØN SØF. ITEMS WHICH ALREADY EXIST WILL NØT BE REGENERATED.
Use DESTROY or EDIT to remove items which are to be regenerated.
- 6326 *** USER WARNING MESSAGE 6326, SUBSTRUCTURE ***, ITEM *** ALREADY EXISTS ØN SØF.
Follows message 6325, above.
- 6327 *** USER INFØRMATION MESSAGES 6327, SUBSTRUCTURE ***, SUBCASE *** IS IDENTIFIED BY *** SET *** IN LØDS ITEM. REFER TØ THIS NUMBER ØN LØADC CARDS.
- 6328 *** SYSTEM FATAL MESSAGE 6328, MØRE THAN 100 SUBCASES DEFINED. SGEN PRØGRAM LIMIT EXCEEDED.
To increase this limit to more than 100 subcases, change the dimensions of local arrays LØAD, MPC, and SPC in subroutine SGEN and change the IF test which causes termination.

DIAGNOSTIC MESSAGES

- 6329 *** USER FATAL MESSAGE 6329, SUBSTRUCTURE ***, REFERENCED ON *** CARD, IS NOT A COMPONENT BASIC SUBSTRUCTURE OF SOLUTION STRUCTURE ***.
- 6330 *** USER FATAL MESSAGE 6330, SOLUTION SUBSTRUCTURE *** -- *** AND *** CARDS CANNOT BE USED TOGETHER. USE EITHER ONE, BUT NOT BOTH.
- 6331 *** USER FATAL MESSAGE 6331, SOLUTION SUBSTRUCTURE *** -- LOADC SET *** REFERENCES UNDEFINED LOAD SET *** OF BASIC SUBSTRUCTURE ***.
- 6332 *** SYSTEM FATAL MESSAGE 6332, CAN'T FIND LOAD VECTOR NUMBER *** IN LOAD MATRIX OF *** COLUMNS BY *** ROWS FOR SOLUTION STRUCTURE ***.
The LOADS item and PVEC item are inconsistent. Possibly they were generated in different Phase 1 runs for a component basic substructure where the Case Control definition of external loads, thermal loads, or element deformations was changed.
- 6333 *** USER FATAL MESSAGE 6333, *** IS AN INVALID FORMAT PARAMETER FOR MODULE EXIO.
- 6334 *** USER WARNING MESSAGE 6334, EXIO DEVICE PARAMETER SPECIFIES TAPE, BUT UNIT *** IS NOT A PHYSICAL TAPE.
- 6335 *** USER WARNING MESSAGE 6335, *** IS AN INVALID DEVICE FOR MODULE EXIO.
- 6336 *** USER INFORMATION MESSAGE 6336, EXIO FILE IDENTIFICATION. PASSWORD ***. DATE ***. TIME *** ** **.
- 6337 *** USER INFORMATION MESSAGE 6337, *** BLOCKS (***) SUPERBLOCKS) OF THE SDF SUCCESSFULLY DUMPED TO EXTERNAL FILE ***.
- 6338 *** USER WARNING MESSAGE 6338, *** IS AN INVALID MODE PARAMETER FOR MODULE EXIO.
- 6339 *** USER WARNING MESSAGE 6339, *** IS AN INVALID FILE POSITIONING PARAMETER FOR MODULE EXIO.
- 6340 *** USER WARNING MESSAGE 6340, SUBSTRUCTURE *** ITEM *** PSEUDO-EXISTS ONLY AND CANNOT BE COPIED OUT BY EXIO.
- 6341 *** USER INFORMATION MESSAGE 6341, SUBSTRUCTURE *** ITEM *** SUCCESSFULLY COPIED FROM *** TO *** (***, ***).
- 6342 *** USER WARNING MESSAGE 6342, SDF RESTORE OPERATION FAILED. THE RESIDENT SDF IS NOT EMPTY. Use the NEW option on the SDF substructure command to create a "new" SDF.
- 6343 *** SYSTEM WARNING MESSAGE 6343, *** IS NOT AN EXTERNAL SDF FILE.
Either (1) tape contained no data, (2) first record read was not an ID or header record, (3) tape was incorrectly positioned, or (4) GINØ buffer size was changed.
- 6344 *** USER INFORMATION MESSAGE 6344, SDF RESTORE OF *** BLOCKS SUCCESSFULLY COMPLETED.

NASTRAN SYSTEM AND USER MESSAGES

- 6345 *** USER WARNING MESSAGE 6345, SUBSTRUCTURE *** ITEM *** IS DUPLICATED ON EXTERNAL FILE ***. OLDER VERSION (***, ***) IS IGNORED.
- 6346 *** USER WARNING MESSAGE 6346, SUBSTRUCTURE *** ITEM *** NOT COPIED. IT ALREADY EXISTS ON THE SDF.
- 6347 *** USER INFORMATION MESSAGE 6347, SUBSTRUCTURE *** ADDED TO THE SDF.
- 6348 *** USER WARNING MESSAGE 6348, SUBSTRUCTURE *** ITEM *** NOT FOUND ON EXTERNAL FILE ***.
- 6349 *** USER INFORMATION MESSAGE 6349, CONTENTS OF EXTERNAL SDF FILE *** FOLLOW.
- 6350 *** USER WARNING MESSAGE 6350, SDF APPEND OF FILE *** FAILED. "text"
"text" explains why the append operation failed.
- 6351 *** USER WARNING MESSAGE 6351, DUPLICATE SUBSTRUCTURE NAME *** FOUND DURING SDF APPEND OF FILE ***. THE SUBSTRUCTURE WITH THIS NAME ON THE FILE BEING APPENDED WILL BE PREFIXED WITH "Q".
- 6352 *** USER INFORMATION MESSAGE 6352, EXTERNAL SDF FILE *** SUCCESSFULLY APPENDED TO THE RESIDENT SDF.
- 6353 *** USER INFORMATION MESSAGE 6353, SUBSTRUCTURE *** ITEM *** HAS BEEN SUCCESSFULLY COMPRESSED.
- 6354 *** USER INFORMATION MESSAGE 6354, THERE ARE *** FREE BLOCKS (*** WORDS) ON THE RESIDENT SDF.
- 6355 *** SYSTEM INFORMATION MESSAGE 6355, EXIO TERMINATED WITH ERRORS. DRY RUN MODE ENTERED.
The parameter DRY has been set to -2 to prevent matrix operations from occurring downstream in this run.
- 6356 *** USER WARNING MESSAGE 6356, *** IS AN INVALID UNIT FOR MODULE EXIO, EXTERNAL FORMAT.
- 6357 *** USER INFORMATION MESSAGE 6357, SUBSTRUCTURE *** ITEM *** SUCCESSFULLY COPIED FROM *** TO ***.
- 6359 *** USER INFORMATION MESSAGE 6359, SUBSTRUCTURE *** WAS ORIGINALLY A SECONDARY SUBSTRUCTURE. ON THIS SDF, IT IS A PRIMARY SUBSTRUCTURE.
- 6361 *** USER INFORMATION MESSAGE 6361, PHASE 1 SUCCESSFULLY EXECUTED FOR SUBSTRUCTURE ***.
- 6362 *** USER FATAL MESSAGE 6362, MPCs SET *** IS ILLEGAL. SUBSTRUCTURE *** GRID POINT *** COMPONENT *** SIGNIFIES A NON-UNIQUE DEPENDENT DEGREE OF FREEDOM.
- 6365 *** USER WARNING MESSAGE 6365, REQUESTED OUTPUT SET ID *** IS NOT DECLARED IN CASE CONTROL, ALL OUTPUT WILL BE PRODUCED.

DIAGNOSTIC MESSAGES

- 6366 *** USER WARNING MESSAGE 6366, THE RECOVER OUTPUT COMMAND SORT MUST APPEAR BEFORE THE FIRST BASIC SUBCOMMAND. ANY OTHER SORT COMMANDS ARE IGNORED.
- 6367 *** USER WARNING MESSAGE 6367, ILLEGAL FORMAT ON THE RECOVER OUTPUT COMMAND ***, COMMAND IGNORED.
- 6368 *** USER WARNING MESSAGE 6368, THE SUBSTRUCTURE *** APPEARING ON A BASIC COMMAND IS NOT A COMPONENT OF ***. ALL OUTPUT REQUESTS UNTIL THE NEXT BASIC, PRINT, OR SAVE ARE IGNORED.

NASTRAN SYSTEM AND USER MESSAGES

- 6501 *** USER FATAL MESSAGE 6501, THE MANUAL COMBINE OPTION HAS BEEN SPECIFIED, BUT NO CONNECTION SET WAS GIVEN.
- 6502 *** USER FATAL MESSAGE 6502, NO NAME HAS BEEN SPECIFIED FOR THE RESULTANT COMBINED PSEUDO-STRUCTURE.
- 6504 *** USER FATAL MESSAGE 6504, A TOLERANCE MUST BE SPECIFIED FOR A COMBINE OPERATION.
- 6505 *** USER FATAL MESSAGE 6505, THE SYMMETRY OPTION *** CONTAINS AN INVALID SYMBOL.
- 6506 *** USER FATAL MESSAGE 6506, THE COMPONENT SUBSTRUCTURE *** IS NOT ONE OF THOSE ON THE COMBINE CARD.
- 6507 *** USER FATAL MESSAGE 6507, THE SUBSTRUCTURE *** DOES NOT EXIST ON THE SDF.
- 6508 *** USER FATAL MESSAGE 6508, THE NAME SPECIFIED FOR THE RESULTANT PSEUDOSTRUCTURE ALREADY EXISTS ON THE SDF.
- 6510 *** USER FATAL MESSAGE 6510, THE REQUESTED COMBINE OPERATION REQUIRES SUBSTRUCTURE BULK DATA WHICH HAS NOT BEEN GIVEN.
- 6511 *** USER FATAL MESSAGE 6511, THE REQUESTED TRANS SET ID *** HAS NOT BEEN DEFINED BY BULK DATA.
- 6512 *** USER FATAL MESSAGE 6512, REDUNDANT CONNECTION SET ID'S HAVE BEEN SPECIFIED.
- 6513 *** USER FATAL MESSAGE 6513, THE TRANS SET ID *** REQUESTED BY A GTRAN BULK DATA CARD HAS NOT BEEN DEFINED.
- 6514 *** USER FATAL MESSAGE 6514, ERRORS HAVE BEEN FOUND IN THE MANUALLY SPECIFIED CONNECTION ENTRIES. SUMMARY FOLLOWS.
- 6515 *** USER FATAL MESSAGE 6515, GRID POINT *** BASIC SUBSTRUCTURE *** DOES NOT EXIST.
- 6516 *** USER INFORMATION MESSAGE 6516, ALL MANUAL CONNECTIONS SPECIFIED ARE ALLOWABLE WITH RESPECT TO TOLER.
- 6517 *** USER FATAL MESSAGE 6517, THE BASIC SUBSTRUCTURE *** REFERRED TO BY A RELES BULK DATA CARD CANNOT BE FOUND IN THE PROBLEM TABLE OF CONTENTS.
- 6518 *** USER FATAL MESSAGE 6518, COMPONENT SUBSTRUCTURE *** ALREADY HAS AN HORG ITEM.
- 6519 *** USER FATAL MESSAGE 6519, REDUNDANT NAMES FOR RESULTANT PSEUDOSTRUCTURE HAVE BEEN SPECIFIED.
- 6520 *** USER FATAL MESSAGE 6520, REDUNDANT VALUES FOR TOLER HAVE BEEN SPECIFIED.
- 6521 *** USER INFORMATION MESSAGE 6521, MODULE COMBI SUCCESSFULLY COMPLETED.

DIAGNOSTIC MESSAGES

- 6522 *** USER FATAL MESSAGE 6522, THE BASIC SUBSTRUCTURE *** REFERRED TO BY A CONCT1 BULK DATA CARD CANNOT BE FOUND IN THE PROBLEM TABLE OF CONTENTS.
- 6523 *** USER FATAL MESSAGE 6523, THE BASIC SUBSTRUCTURE *** REFERRED TO BY A CONCT BULK DATA CARD CANNOT BE FOUND IN THE PROBLEM TABLE OF CONTENTS.
- 6524 *** USER INFORMATION MESSAGE 6524, ***** COLUMNS OF THE CENTER MATRIX CAN BE PUT IN CORE FOR THE CURRENT MPY3 EXECUTION.
- 6525 *** USER INFORMATION MESSAGE 6525, ESTIMATED TIME FOR THE CURRENT MPY3 EXECUTION IS ***** SECONDS.
- 6526 *** USER INFORMATION MESSAGE 6526, THE CENTER MATRIX IS TOO LARGE FOR IN-CORE PROCESSING. OUT-OF-CORE PROCESSING WILL BE PERFORMED.
- 6528 *** USER FATAL MESSAGE 6528, INCOMPATIBLE LOCAL COORDINATE SYSTEMS HAVE BEEN FOUND. CONNECTION OF POINTS IS IMPOSSIBLE, SUMMARY FOLLOWS.
- 6530 *** USER FATAL MESSAGE 6530, THE BASIC SUBSTRUCTURE *** REFERRED TO BY A GTRAN CARD CANNOT BE FOUND IN THE PROBLEM TABLE OF CONTENTS.
- 6531 *** USER FATAL MESSAGE 6531, NO CONNECTIONS HAVE BEEN FOUND DURING THE AUTOMATIC CONNECTION PROCEDURE.
- 6532 *** USER FATAL MESSAGE 6532, THE GNEW OPTION IS NOT CURRENTLY AVAILABLE.
- 6533 *** USER FATAL MESSAGE 6533, OPTIONS PA HAS BEEN SPECIFIED BUT THE LOOP ITEM ALREADY EXISTS FOR SUBSTRUCTURE ***.
- 6534 *** USER FATAL MESSAGE 6534, OPTIONS PA HAS BEEN SPECIFIED BUT THE SUBSTRUCTURE *** DOES NOT EXIST.
- 6551 *** USER FATAL MESSAGE 6551, MATRIX B IN MPY3 IS NOT SQUARE.
- 6553 *** USER FATAL MESSAGE 6553, NO. OF ROWS OF MATRIX A IN MPY3 IS UNEQUAL TO NO. OF COLUMNS OF MATRIX B.
- 6554 *** USER FATAL MESSAGE 6554, NO. OF COLUMNS OF MATRIX E IN MPY3 IS UNEQUAL TO NO. OF COLUMNS OF MATRIX A.
- 6555 *** USER FATAL MESSAGE 6555, MATRIX E IN MPY3 IS NOT SQUARE FOR $A(T)BA + E$ PROBLEM.
- 6556 *** USER FATAL MESSAGE 6556, NO. OF ROWS OF MATRIX E IN MPY3 IS UNEQUAL TO NO. OF ROWS OF MATRIX B FOR $BA + E$ PROBLEM.
- 6557 *** USER FATAL MESSAGE 6557, UNEXPECTED NULL COLUMN OF $A(T)$ ENCOUNTERED.

NASTRAN SYSTEM AND USER MESSAGES

- 6601 *** USER FATAL MESSAGE 6601, REQUEST TO REDUCE PSEUDOSTRUCTURE *** INVALID. DOES NOT EXIST ON THE SDF.
- 6602 *** USER FATAL MESSAGE 6602, THE NAME *** CANNOT BE USED FOR THE REDUCED PSEUDOSTRUCTURE. IT ALREADY EXISTS ON THE SDF.
- 6603 *** USER FATAL MESSAGE 6603, A BOUNDARY SET MUST BE SPECIFIED FOR A REDUCE OPERATION.
- 6604 *** USER WARNING MESSAGE 6604, A BOUNDARY SET HAS BEEN SPECIFIED FOR ***, BUT IT IS NOT A COMPONENT OF THE PSEUDOSTRUCTURE BEING REDUCED. THE BOUNDARY SET WILL BE IGNORED.
- 6605 *** USER WARNING MESSAGE 6605, A BOUNDARY SET HAS BEEN SPECIFIED FOR *** BUT IT IS NOT A PHASE1 BASIC SUBSTRUCTURE. THE BOUNDARY SET WILL BE IGNORED.
- 6606 *** USER FATAL MESSAGE 6606, BOUNDARY SET *** SPECIFIED IN CASE CONTROL HAS NOT BEEN DEFINED BY BULK DATA.
No BDYC bulk data has been entered.
- 6607 *** USER FATAL MESSAGE 6607, NO BDYS OR BDYS1 BULK DATA HAS BEEN INPUT TO DEFINE BOUNDARY SET ***.
- 6608 *** USER FATAL MESSAGE 6608, THE REQUEST FOR BOUNDARY SET ***, SUBSTRUCTURE *** WAS NOT DEFINED.
- 6609 *** USER INFORMATION MESSAGE 6609, NO BOUNDARY SET HAS BEEN SPECIFIED FOR COMPONENT *** OF PSEUDOSTRUCTURE ***. ALL DEGREES OF FREEDOM WILL BE REDUCED.
- 6610 *** USER WARNING MESSAGE 6610, DEGREES OF FREEDOM AT GRID POINT *** COMPONENT SUBSTRUCTURE *** INCLUDED IN A BOUNDARY SET DO NOT EXIST. REQUEST WILL BE IGNORED.
- 6611 *** USER FATAL MESSAGE 6611, GRID POINT *** SPECIFIED IN BOUNDARY SET *** FOR SUBSTRUCTURE *** DOES NOT EXIST.
- 6612 *** USER FATAL MESSAGE 6612, THE REDUCE OPERATION REQUIRES SUBSTRUCTURE BULK DATA WHICH HAS NOT BEEN GIVEN.
- 6613 *** USER FATAL MESSAGE 6613, FOR RUN=GO, THE REDUCED SUBSTRUCTURE *** MUST ALREADY EXIST.
- 6614 *** USER FATAL MESSAGE 6614, ILLEGAL OR NON-EXISTANT STRUCTURE NAME USED ABOVE.
- 6615 *** USER FATAL MESSAGE 6615, ILLEGAL BOUNDARY SET IDENTIFICATION NUMBER.
- 6616 *** USER INFORMATION MESSAGE 6616, MODULE REDUCE SUCCESSFULLY COMPLETED.

DIAGNOSTIC MESSAGES

- 6900 *** USER INFORMATION MESSAGE 6900, LOADS HAVE BEEN SUCCESSFULLY APPENDED FOR SUBSTRUCTURE ***.
- 6901 *** USER INFORMATION MESSAGE 6901, ADDITIONAL LOADS HAVE BEEN SUCCESSFULLY MERGED FOR SUBSTRUCTURE.
- 6951 *** USER FATAL MESSAGE 6951, INSUFFICIENT CORE TO LOAD TABLES. IN MODULE LODAPP, CORE = ***.
- 6952 *** USER FATAL MESSAGE 6952, REQUESTED SUBSTRUCTURE *** DOES NOT EXIST.
- 6953 *** SYSTEM FATAL MESSAGE 6953, A WRONG COMBINATION OF LOAD VECTORS EXISTS FOR SUBSTRUCTURE ***.
- 7019 *** USER INFORMATION MESSAGE 7019. MODULE DSCHK IS EXITING FOR REASON *** ON ITERATION NUMBER ***** / PARAMETER VALUES ARE AS FOLLOWS DONE = *****, SHIFT = *****, DSEPSI = *****.

See Section 3.5 for a discussion of Rigid Format 4 output features.

NASTRAN DICTIONARY

7.1 NASTRAN DICTIONARY

This section contains descriptions of mnemonics, acronyms, phrases, and other commonly used NASTRAN terms. The first column of the Dictionary contains the NASTRAN terms in alphabetical order. The second column contains a code indicating a general category for each term. The codes and categories, along with general references to the Programmer's Manual and User's Manual, are as follows:

<u>Code</u>	<u>Category</u>	<u>General Reference</u>
IA	Input - Executive Control	UM-2.2
IB	Input - Bulk Data	UM-2.4
IC	Input - Case Control	UM-2.3
EM	Executive Module	UM-5.3.4
FMH	Functional Module - Heat	PM-4
FMS	Functional Module - Structural	PM-4
FMM	Functional Module - Matrix Operation	UM-5.3.1
FMU	Functional Module - Utility	UM-5.3.2
FMX	Functional Module - User	UM-5.3.3
DBM	Data Block - Matrix	PM-2
DBML	Data Block - Matrix List	PM-2
DBT	Data Block - Table	PM-2
P	Parameter Name	UM-3
PU	Parameter set by user	UM-2.4
L	Rigid Format Label	UM-3
PH	Common Phrase or Term	
M	Miscellaneous	

The third column of the Dictionary contains a definition or description of the terms given in the first column. References to the User's Manual are indicated by UM-i and the Programmer's Manual by PM-i, where i is the section number of the manual. References to particular rigid formats are indicated by D-i where i is the displacement approach rigid format number.

NASTRAN DICTIONARY

A	P	Parameter value used to control utility module MATGPR print of A-set matrices.
ABFL	DBM	$[A_{b,fl}]$ - Hydroelastic boundary area factor matrix.
ABFLT	DBM	Transpose of $[A_{b,fl}]$
ACCE	IC	Abbreviated form of ACCELERATION.
ACCELERATION	IC	Output request for acceleration vector. (UM-2.3, 4.2)
ACPT	DBT	Aerodynamic Connection and Property Data.
Active Column	PH	Column containing at least one nonzero term outside the band.
ADD	FMM	Functional module to add two matrices together.
ADD	M	Parameter constant used in utility module PARAM.
ADD5	FMM	Functional module to add up to five matrices together.
ADUMi	IB	Defines attributes of dummy elements 1 through 9.
AEFACT	IB	Specifies box division points.
AERØ	DBT	Aerodynamic Matrix Generation Data.
AERØ	IB	Gives basic aerodynamic parameters.
AJJL	DBML	Aerodynamic Influence Matrix List.
ALL	IC	Output request for all of a specified type of output.
ALLEDGE TICS	IC	Request tic marks on all edges of X-Y plot.
ALTER	IA	Alter statement for DMAP or rigid format.
ALWAYS	P	Parameter set to -1 by a PARAM statement in the Piecewise Linear Analysis Rigid Format (D-6).
AMG	FMS	Aerodynamic Matrix Generator.
AMP	FMS	Aerodynamic Matrix Processor.
AND	M	Parameter constant used in executive module PARAM.
AØUT\$	M	Indicates restart with solution set output request.
APD	FMS	Aerodynamic Pool Distributor.
APP	IA	Control card which specifies approach (DISP or DMAP).
APPEND	M	File may be extended (see FILE).
ASET	IB	Analysis set coordinate definition card.
ASET1	IB	Analysis set coordinate definition card.
AUTØ	IC	Requests X-Y plot of autocorrelation function.
AUTØ	DBT	Autocorrelation function table.

NASTRAN DICTIONARY

AXES	IC	Defines orientation of object for structure plot.
AXIC	DBT	Generated by Input File Processor 3 (IFP3) for axisymmetric conical shell problems.
AXIC	IB	Axisymmetrical conical shell definition card. When this card is present, most other bulk data cards may not be used.
AXIF	IB	Controls the formulation of a hydroelastic problem.
AXISYM\$	M	Indicates restart with conical shell or hydroelastic elements.
AXISYMMETRIC	IC	Selects boundary conditions for axisymmetric shell problems or specifies the existence of hydroelastic fluid harmonics.
AXSLØT	IB	Controls the formulation of acoustic analysis problems.

NASTRAN DICTIONARY

B	PH	Upper semiband of matrix
B2DD	DBM	$[B_{dd}^2]$ - Partition of direct input damping matrix.
B2PP	DBM	$[B_{pp}^2]$ - Direct input damping matrix for all physical points.
B2PP	IC	Selects direct input matrices - input on DMIG bulk data cards for use in Dynamics Rigid Formats (D-7 thru D-12).
B2PP\$	M	Indicates restart with change in direct input damping matrices.
BAA	DBM	$[B_{aa}]$ - Partition of damping matrix
BALL EDGE TICS	IC	Request for all edge tic marks to be plotted on lower frame of an X-Y plot.
BAR	IC	Requests structure plot for all bar elements.
BARØR	IB	Bar orientation default definition.
BBAR	PH	Lower semiband of matrix.
BDD	DBM	$[B_{dd}]$ - Damping matrix used in direct formulation of dynamics problems (D-7 thru D-9).
BDEBA	P	Parameter used to indicate equivalence of BDD and BAA.
BDPØØL	DBT	Hydroelastic boundary description table.
BDYLIST	IB	Structure-fluid hydroelastic boundary definition.
BEGIN	EM	The first DMAP statement is always BEGIN.
BEGIN BULK	IB	Control card which marks the end of the case control deck. Cards following this card are assumed to be bulk data cards.
BETA	P	Factor in integration algorithm in transient heat transfer analysis.
BFF	DBM	$[B_{ff}]$ - Partition of damping matrix.
BGG	DBM	$[B_{gg}]$ - Damping matrix generated by Structural Matrix Assembler.
BGPA	DBT	Basic Grid Point Definition Table - aerodynamics.
BGPDT	DBT	Basic grid point definition table.
BHH	DBM	$[B_{hh}]$ - Partition of damping matrix.
BKLO	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis Rigid Format (D-5).
BKL1	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis Rigid Format (D-5).
BL	IC	Requests Benson Lehner plotter.
BLANK FRAMES	IC	Requests blank frames between structure plots (UM-4.1).
BLEFT TICS	IC	Request for left edge tic marks to be plotted on bottom frame of an X-Y plot.

NASTRAN DICTIONARY

BMG	FMS	Generates DMIG card images describing interconnection of fluid and structure.
BNN	DBM	$[B_{nn}]$ - Partition of damping matrix.
BØTH	IC	Bulk data echo option - Requests both unsorted and sorted printout of bulk data deck.
BPI	IC	Bits per inch - Plot tape density must be specified on control cards in addition to this data card. The required value will vary from one installation to another.
BQG	DBM	Single-point forces of constraint for a Buckling Analysis problem (D-5).
BRIGHT TICS	IC	Request for right edge tic marks to be plotted on bottom frame for X-Y plot.
BUCKLING	IA	Selects rigid format for buckling analysis.
BUCKLING	P	Constant parameter value used in functional module READ in the Buckling Analysis Rigid Format (D-5).
BUCKLING	P	Used in printing rigid format error messages for Buckling Analysis (D-5).
Bulk Data Deck	PH	The third of the three data decks necessary to run a problem under the NASTRAN system. This deck begins with the BEGIN BULK card and ends with the ENDDATA card, and contains the data of the mathematical model. The format of each bulk data card is fixed field, 8 or 16 columns for each value.
BXHH	DBM	Total modal damping matrix - h set.

NASTRAN DICTIONARY

C	M	Used in parameter section of DMAP statement. Indicates that parameter is a constant.
C	PH	Symbol for active column in triangular decomposition (\bar{C} used for active rows).
CAERØ1	IB	Defines aerodynamic macro-element.
CALCØMP	IC	Request California Computer plotter.
CAMERA	IC	Selects one or both of the two cameras for the SC 4020 cathode ray tube electronic plotter. This information must usually also be given to the plotter operator on the run submittal slip which will vary from one installation to another. (UM-4)
CARDNØ	P	Parameter used to accumulate a count of all card output punched except the NASTRAN restart dictionary.
CASE	FMS	Extracts user request from CASECC for current loop in dynamics rigid formats (D-7 thru D-12).
Case Control Deck	PH	The second of the three data decks necessary to run a problem under the NASTRAN system. It contains cards which select particular data sets from the Bulk Data Deck, output request cards and titling information. Cards in this deck are free field.
CASECC	DBT	Case control data block.
CASEXX	DBT	Case control data block as modified by functional module CASE.
CASEYY	DBT	Appended case control data table.
CASEZZ	DBT	CASEYY reduced to ØFREQ list.
CAXIF2	IB	Acoustic core element connection definition card.
CAXIF3	IB	Acoustic triangular element connection definition card.
CAXIF4	IB	Acoustic quadrilateral element connection definition card.
CBAR	IB	Bar element connection definition card.
CCØNEAX	IB	Axisymmetrical conical shell element connection card.
CDAMP1	IB	Scalar damper connection definition card.
CDAMP2	IB	Scalar damper property and connection definition card.
CDAMP3	IB	Scalar damper connection definition card (connecting scalar points).
CDAMP4	IB	Scalar damper property and connection definition card (connecting scalar points).
CDUMi	IB	Defines definition card for dummy elements 1 through 9.
CEAD	FMS	Complex Eigenvalue Analysis - Displacement.
CEIG	P	Parameter used in SDR2 in Complex Eigenvalue Analysis (D-7 and D-10).

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CEIGN	P	Parameter used in VDR in Complex Eigenvalue Analysis (D-7 and D-10).
CELAS1	IB	Scalar spring connection definition card.
CELAS2	IB	Scalar spring property and connection definition card.
CELAS3	IB	Scalar spring connection definition card (connecting scalar points).
CELAS4	IB	Scalar spring property and connecting definition card (connecting scalar points).
CEND	IA	The last card of the Executive Control Deck.
CFLUID2	IB	Fluid core element connection definition card.
CFLUID3	IB	Fluid triangular element connection definition card.
CFLUID4	IB	Fluid quadrilateral element connection definition card.
CHBDY	IB	Boundary element connection definition card for heat transfer analysis.
Checkpoint	PH	The process of writing selected data blocks onto the New Problem Tape for subsequent restarts.
CHEXA1	IB	Hexahedron element connection definition card - five tetrahedra.
CHEXA2	IB	Hexahedron element connection definition card - ten tetrahedra.
CHKPNT	EM	Checkpoint module.
CHKPNT	IA	Request for checkpoint execution.
CLAMA	DBT	Complex eigenvalue output table.
CLAMAL	DBT	Appended case control data table.
CLAMAL1	DBT	CLAMAL reduced to ØFREQ list.
CLEAR	IC	Causes all parameter values used for X-Y plots to be reset to their default values except plotter and the titles (UM-4.2).
CMASS1	IB	Scalar mass connection definition card.
CMASS2	IB	Scalar mass property and connection definition card.
CMASS3	IB	Scalar mass connection definition card (connecting scalar points).
CMASS4	IB	Scalar mass property and connection definition card (connecting scalar points).
CMETHØD	IC	Complex eigenvalue analysis method selection.
CMETHØD\$	M	Indicates restart with change in complex eigenvalue analysis method selection.
CMPLV	P	Parameter used in GKAD to indicate complex eigenvalue problem.

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Cold Start	PH	A NASTRAN problem initiated at its logical beginning. A cold start will never use an Old Problem Tape but it may create a New Problem Tape for subsequent restarts.
CØLØR	IC	Selects ink color for table plotters (UM-4.1).
CØND	EM	Conditional transfer
CØNM1	IB	Structural mass element connection definition card.
CØNM2	IB	Structural mass element connection definition card.
CØNRØD	IB	Rod element property and connection definition card.
CØNRØD	IC	Requests structure plot for all CØNRØD elements.
CØRD1C	IB	Cylindrical coordinate system definition (by grid point ID).
CØRD1R	IB	Rectangular coordinate system definition (by grid point ID).
CØRD1S	IB	Spherical coordinate system definition (by grid point ID).
CØRD2C	IB	Cylindrical coordinate system definition (by coordinates).
CØRD2R	IB	Rectangular coordinate system definition (by coordinates).
CØRD2S	IB	Spherical coordinate system definition (by coordinates).
CØSINE	IC	Indicates cosine boundary conditions for conical shell problem.
CØUPMASS	P	Parameter used to request coupled mass.
CPBAR	P	Selects coupled mass option for BAR element.
CPHID	DBM	Complex Eigenvectors - solution set.
CPHIH1	DBM	PHIHL reduced to ØFREQ list.
CPHIP	DBM	Complex Eigenvectors - physical set.
CPQDPLT	P	Selects coupled mass option for QDPLT element.
CPQUAD1	P	Selects coupled mass option for QUAD1 element.
CPQUAD2	P	Selects coupled mass option for QUAD2 element.
CPRØD	P	Selects coupled mass option for RØD and CØNRØD elements.
CPTRBSC	P	Selects coupled mass option for TRBSC element.
CPTRIA1	P	Selects coupled mass option for TRIA1 element.
CPTRIA2	P	Selects coupled mass option for TRIA2 element.
CPTRPLT	P	Selects coupled mass option for TRPLT element.
CPTUBE	P	Selects coupled mass option for TUBE element.
CQMEM	IB	Quadrilateral membrane element connection definition card.
CQMEM1	IB	Isoparametric quadrilateral membrane element connection definition card.

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CQDMEM2	IB	Quadrilateral membrane element connection definition card.
CQDPLT	IB	Quadrilateral bending element connection definition card.
CQUAD1	IB	General Quadrilateral element connection definition card.
CQUAD2	IB	Homogeneous quadrilateral element connection definition card.
CRØD	IB	Rod element connection definition card.
CSHEAR	IB	Shear panel element connection definition card.
CSLØT3	IB	Triangular slot element connection definition card for acoustic analysis.
CSLØT4	IB	Quadrilateral slot element connection definition card for acoustic analysis.
CSTM	DBT	Coordinate System Transformation Matrices.
CSTMA	DBT	Coordinate System Transformation Matrices - Aerodynamics.
CTETRA	IB	Tetrahedron element connection definition card.
CTØRDRG	IB	Toroidal ring element connection card.
CTRAPRG	IB	Trapezoidal ring element connection card.
CTRBSC	IB	Basic bending triangular element connection definition card.
CTRIA1	IB	General triangular element connection definition card.
CTRIA2	IB	Homogeneous triangular element connection definition card.
CTRIARG	IB	Triangular ring element connection card.
CTRMEM	IB	Triangular membrane element connection definition card.
CTRPLT	IB	Triangular bending element connection definition card.
CTUBE	IB	Tube element connection definition card.
CTWIST	IB	Twist panel element connection definition card.
CURVLINESYMBOL	IC	Request to connect points with lines and/or to use symbols for X-Y plots.
CVISC	IB	Viscous damper element connection definition card.
CWEDGE	IB	Wedge element connection definition card.

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D	P	Parameter value used to control utility module MATGPR print of solution set matrices.
DAREA	IB	Dynamic load scale card.
Data Block	PH	Designates a set of data (matrix, table) occupying a file. A file is "allocated" to a data block and a data block is "assigned" to a file.
Data Pool File	PH	An executive file containing the ØSCAR and any data blocks pooled by the Executive Segment File Allocator (XSFA) module. The contents of this file are described within the data pool dictionary (DPL).
DD	IC	Requests Data Display plotter.
DDR	FMX	This module is reserved for user implementation.
DDR1	FMS	Dynamic Data Recovery - Phase 1.
DDR2	FMS	Dynamic Data Recovery - Phase 2.
Deck	PH	1. NASTRAN Data Deck 2. Executive Control Deck 3. Case Control Deck 4. Bulk Data Deck 5. Restart Deck
DECOMØPT	P	Controls type of arithmetic used in the decomposition for frequency-response problems.
DECOMØP	FMM	To decompose a square matrix into upper and lower triangular factors.
Default	PH	Many NASTRAN data items have default values supplied by the system. For example, the default value for MAXLINES is 20000.
DEFØRM	IB	Enforced element deformation definition card.
DEFØRM	IC	Enforced element deformation set selection.
DEFØRM\$	M	Indicates restart with change in enforced element deformation selection.
DEFØRMATION	IC	Indicates subcases to be used for deformed structure plots.
DELAY	IB	Dynamic load time delay card.
Delete	IB	Delete cards from Bulk Data Deck.
DELTAPG	DBM	Incremental load vector in Piecewise Linear Analysis Rigid Format (D-6).
DELTAQG	DBM	Incremental vector of single point constraint forces in the Piecewise Linear Analysis Rigid Format (D-6).
DELTAUGV	DBM	Incremental displacement vector in the Piecewise Linear Analysis Rigid Format (D-6).
DENSITY	IC	Density of lines for SC 4020 plotter.
DENSITY	IC	Plot tape density must be specified to plotter operator on run submittal form and will vary from one installation to another (UM-4.1).

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DESTROY	P	Appended AJJL parameter.
DET	IB	Eigenvalue analysis method option - determinant (see EIGR, EIGB, EIGC).
DIFF	P	Parameter used in the Piecewise Linear Analysis Rigid Format (D-6).
DIFFERENTIAL STIFFNESS	IA	Selects rigid format for static analysis with differential stiffness.
DIFFSTIF	P	Parameter used in the PRTPARM module in the Differential Stiffness Rigid Format (D-4).
DIRCEAD	P	Used in printing rigid format error messages for direct complex eigenvalue analysis (D-7).
DIRECT	P	Parameter used to indicate direct formulation of dynamics problems (D-7 thru D-9).
DIRECT COMPLEX EIGENVALUES	IA	Selects rigid format for direct complex eigenvalue analysis.
DIRECT FREQUENCY RESPONSE	IA	Selects rigid format for direct frequency and random response.
DIRECT TRANSIENT RESPONSE	IA	Selects rigid format for direct transient response.
DIRFRRD	P	Used in printing rigid format error messages for direct frequency response.
DIRTRD	P	Used in printing rigid format error messages for direct transient response (D-9).
DISP	IA	Displacement approach to structural analysis.
DISP	IC	Abbreviated form of DISPLACEMENT.
DISPLACEMENT	IC	Request for output of displacement vector or eigenvector. (UM-2.3, 4.2)
DIT	DBT	Direct Input Table.
DIV	P	Parameter constant used in utility module PARAM.
DLØAD	IB	Dynamics load assembly definition.
DLØAD	IC	Dynamic load set solution request.
DLØAD\$	M	Indicates restart with change in dynamic load set request.
DLT	DBT	Dynamic Loads Table.
DM	DBM	[D] - Rigid body transformation matrix.
DMAP	IA	Approach option (Direct Matrix Abstraction Program).
DMAP Instruction	PH	A statement in the DMAP Language.
DMAP Language	PH	Data block-oriented language used by the NASTRAN Executive System to direct the sequence and flow of modules to be executed.

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DMAP Loop	PH	A DMAP sequence to be repeated, initiated with a LABEL DMAP instruction and terminated by a REPT DMAP instruction.
DMAP Module	PH	A module called by means of a DMAP instruction.
DMAP Sequence	PH	A set of DMAP instructions.
DMI	IB	Direct Matrix Input (data block is defined and used by user).
DMIAX	IB	Direct Matrix Input - Axisymmetric, used in dynamic rigid formats (D-7 thru D-12).
DMIG	IB	Direct Matrix Input - used in dynamic rigid formats (D-7 thru D-12).
DPD	FMS	Dynamic Pool Distributor.

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DPH	M	Data Pool Housekeeper - Executive routine.
DPHASE	IB	Dynamic load phase lead card.
DSO	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DS1	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DSCØ	IC	Abbreviated form of DSCØEFFICIENT.
DSCØ\$	M	Indicates restart with change in differential stiffness load factors.
DSCØEFFICIENT	IC	Selects set of differential stiffness factors which have been input on DSFACT cards.
DSCØSET	P	Differential Stiffness coefficient set number. Used in the Differential Stiffness Rigid Format (D-4).
DSFACT	IB	Differential stiffness factor set definition card.
DSLØØP	P	Controls DMAP looping in the Differential Stiffness Rigid Format (D-4).
DSMG1	FMS	Differential Stiffness Matrix Generator - Phase 1.
DSMG2	FMS	Differential Stiffness Matrix Generator - Phase 2.
DTI	IB	Direct Table Input - means by which user may directly input any table data block.
DUMMØD1	FMX	This module is reserved for user implementation.
DUMMØD2	FMX	This module is reserved for user implementation.
DUMMØD3	FMX	This module is reserved for user implementation.
DUMMØD4	FMX	This module is reserved for user implementation.
Dummy Element	PH	Provision for user to insert additional finite element into the NASTRAN element library.
Dump	PH	Printed output of contents of all, or a portion, of main memory at some point in the problem solution.
DYNAMICS	DBT	Generated by the Input File Processor (IFP) for Real Eigenvalue, Buckling, or any of the Dynamics Rigid Formats (D-3, D-5 and D-7 thru D-12).
D1JE	DBM	Downwash factors due to extra points - real.
D2JE	DBM	Downwash factors due to extra points - complex.
D1JK	DBM	Real part of downwash matrix.
D2JK	DBM	Imaginary part of downwash matrix.

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E	P	Parameter value used by MATGPR to print matrices associated with extra points.
EAI	IC	Requests EAI 3500 plotter.
ECHØ	IC	Ouput request statement for echo of bulk data.
ECPT	DBT	Element Connection and Properties Table.
ECPTNL	DBT	Nonlinear subset of the ECPT. This data block is used only in the Piecewise Linear Analysis Rigid Format (D-6).
ECPTNL1	DBT	Updated version of the ECPTNL data block. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ECPTNLPG	P	Error flag for the Piecewise Linear Analysis Rigid Format (D-6). If all elements in a piecewise linear analysis problem are linear, this error flag is set and a DMAP exit occurs.
ECT	DBT	Element Connection Table.
ECTA	DBT	Element Connection Table - Aerodynamics.
EDT	DBT	Enforced Deformation Table - generated by Input File Processor.
EED	DBT	Eigenvalue Extraction Data table (D-3, D-5, D-7, D-10, D-11, D-12).
EIGB	IB	Real eigenvalue extraction data for buckling analysis (D-5).
EIGC	IB	Complex eigenvalue extraction data card (D-7 and D-10).
EIGP	IB	Complex eigenvalue pole definition card (D-7 and D-10).
EIGR	IB	Real eigenvalue extraction data for normal mode analysis (D-3, D-10 thru D-12).
ELEMENTS	IC	Used in element set definition for structure plot.
ELFØRCE	IC	Ouput request card for element forces. (UM-2.3, 4.2).
ELSETS	DBT	Element plot set connection tables.
ELSTRESS	IC	Request for output of element stresses.(UM-2.3, 4.2)
END	IA	END is the last statement in all DMAP sequences.
ENDALTER	IA	Last card of alter packet.
ENDDATA	IB	End of Bulk Data Deck.
EØF	PH	End-of-File.
EPØINT	IB	Extra point definition card - used in dynamics problems only.
EPSHT	P	Used in convergence tests for nonlinear heat transfer analysis.
EPSILØN SUB E (ϵ_e)	PH	Error ratio computed in SSG3. $\epsilon_e = \epsilon_\ell$ if the referenced load is $\{P_\ell\}$ and $\epsilon_e = \epsilon_0$ if the referenced load is $\{P_0\}$. See page 3.2-10 for mathematical definition of ϵ_0 and ϵ_ℓ .
EPT	DBT	Element Property Table - output by Input File Processor.

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EQAERØ	DBT	Equivalence between external points and scalar index values - Aerodynamics.
EQDYN	DBT	Equivalence of internal and external indices - dynamics.
EQEXIN	DBT	Equivalence of internal and external indices.
EQUIV	EM	Equivalence data blocks.
Equivalence	PH	Data blocks are considered equivalenced when references to their equivalent names access the same physical data file.
ERRØR1	L	Label used when rigid format errors are detected.
ERRØR2	L	Label used when rigid format errors are detected.
ERRØR3	L	Label used when rigid format errors are detected.
ERRØR4	L	Label used when rigid format errors are detected.
ERRØR5	L	Label used when rigid format errors are detected.
ERRØR6	L	Label used when rigid format errors are detected.
EST	DBT	Element Summary Table.
ESTL	DBT	Element Summary Table for Linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL	DBT	Element Summary Table for Nonlinear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL1	DBT	Updated version of the ESTNL data block. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
EXCEPT	IC	Forms exceptions to string of values in set declarations.
EXCLUDE	IC	Used in set definition for structure plots.
Executive	PH	1. Executive Control Deck 2. NASTRAN Executive System
Executive Control Deck	PH	The first of the three data decks necessary to run a problem under the NASTRAN system. This deck begins with the ID card and ends with the CEND card. Among other things, cards in this deck select the solution approach and rigid format to be used, limit the execution time, and control checkpointing and restart.
Executive System	PH	The Executive System initiates a NASTRAN problem solution via the Preface, allocates files to data blocks during problem solution, controls the sequence of the modules to be executed, and provides for problem restart capability.
EXIT	EM	Program termination DMAP statement.
External Sort	PH	Order of grid, scalar and extra points determined by the user's numerical order of point identification.
Extra Point	PH	A "point" which is defined on an EPØINT bulk data card. An extra point has no geometrical coordinates, defines only one degree of freedom of the model and is used only in dynamics solutions.

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F	P	Parameter value used by MATGPR to print F-set matrices.
FA1	FMS	Flutter Analysis - Phase 1.
FA2	FMS	Flutter Analysis - Phase 2.
FBS	FMM	Forward and Backward Substitution.
FE	P	Parameter used by MATGPR to print out FE-set matrices.
FIAT	M	File Allocation Table. Core resident executive table where data block names, status of the data blocks (assigned to a file, purged, equivalenced, etc.) and trailer for the data blocks are stored.
FILE	IA	Term appearing on the checkpoint dictionary cards indicating the file number (internal) associated with a particular data block.
FILE	M	The FILE DMAP statement specifies data block characteristics such as TAPE, SAVE, and APPEND.
File	PH	Designates an auxiliary storage area or unit.
FIND	IC	Selects parameters for structure plot.
FINIS	L	Label used in all displacement rigid format DMAPs to terminate execution of DMAP.
Finite Element	PH	Idealized unit of a structural model that represents the distributed elastic properties of a structure.
FIST	M	File Status Table. Core resident executive table where internal file names and pointers to the FIAT, pertaining only to the module being executed, are stored.
FLAGS	IA	Term appearing on the checkpoint dictionary cards indicating the status of a data block (equivalenced or not).
FLFACT	IB	Specifies densities, Mach numbers and frequencies.
FLIST	DBT	Flutter Control Table.
FLØØP	P	Flutter loop counter/control.
FLSYM	IB	Structural symmetry definition card for use in hydroelastic problems.
FLUID	IC	Indicates hydroelastic harmonic degrees of freedom.
FLUTTER	IB	Defines flutter data.
FMETHØD	IC	Flutter Analysis Method Selection.
FMØDE	P	Mode number of first mode selected by user in modal dynamics formulations.
FØRCE	IB	Static load definition (vector).
FØRCE	IC	Request for output of element forces.
FØRCE1	IB	Static load definition (magnitude and two grid points).

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FØRCE2	IB	Static load definition (magnitude and four grid points).
FØRCEAX	IB	Static load definition for conical shell problem.
FREEPT	IB	Defines point on a free surface of a fluid for output purposes.
FREQ	IB	Frequency list definition.
FREQ\$	M	Indicates restart with change in frequencies to be solved.
FREQ1	IB	Frequency list definition (linear increments).
FREQ2	IB	Frequency list definition (logarithmic increments).
FREQRESP	P	Parameter used in SDR2 to indicate a frequency response problem.
FREQUENCY	IC	Selects the set of frequencies to be solved in frequency response problems.
FRL	DBT	Frequency Response List.
FRQSET	P	Used in FRRD to indicate user selected frequency set.
FRRD	FMS	Frequency and Random Response - Displacement approach.
FSAVE	DBT	Flutter Storage Save Table.
FSLIST	IB	Defines a free surface of a fluid in a hydroelastic problem.
Functional Module	PH	An independent group of subroutines that perform a structural analysis function.

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G	P	1. Parameter used by MATGPR to print G-set matrices. 2. Parameter used to input uniform structural damping coefficient (D-7 thru D-9).
GEI	DBT	General Element Input.
GENEL	IB	General element definition.
GEØM1	DBT	Geometric data input table - generated by the Input File Processor.
GEØM2	DBT	Connection input table - generated by the Input File Processor.
GEØM3	DBT	Static load and temperature input table - generated by the Input File Processor.
GEØM4	DBT	Displacement sets definition input table - generated by the Input File Processor.
GI	FMS	Geometry Interpolator.
GINØ	M	General input/output. GINØ is a collection of subroutines which is the input/output control system for NASTRAN.
GINØ Buffer	PH	Storage reserved in open core for each GINØ file opened. The size of the buffer is machine dependent.
GINØ File Number	PH	File number used internally in DMAP modules to access data blocks.
GIV	IB	Eigenvalue analysis method option - Givens (see EIGR).
GKAD	FMS	General [K] Assembler - Direct.
GKAM	FMS	General [K] Assembler - Modal.
GM	DBM	$[G_m]$ - multipoint constraint transformation matrix.
GMD	DBM	$[G_m^d]$ - multipoint constraint transformation matrix used in dynamic analysis.
GNFIAT	M	Generate FIAT. The preface routine which generates the initial FIAT.
GØ	DBM	$[G_o]$ - structural matrix partitioning transformation matrix.
GØD	DBM	$[G_o^d]$ - Structural matrix partitioning transformation matrix used in dynamic analysis.
GP1	FMS	Geometry Processor - part 1.
GP2	FMS	Geometry Processor - part 2.
GP3	FMS	Geometry Processor - part 3.
GP4	FMS	Geometry Processor - part 4.
GPCT	DBT	Grid Point Connection Table.
GPDT	DBT	Grid Point Definition Table.
GPI	M	General Problem Initialization (see XGPI).
GPL	DBT	Grid Point List.

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GPLA	DBT	Grid Point List - Aerodynamics.
GPLD	DBT	Grid Point List used in dynamic analysis.
GPSETS	DBT	Grid point plot sets.
GPSP	FMS	Grid Point Singularity Processor.
GPST	DBT	Grid Point Singularity Table.
GPTT	DBT	Grid Point Temperature Table.
GPWG	FMS	Grid Point Weight Generator.
GRAV	IB	Gravity vector definition card.
GRDPNT	P	Used in all displacement rigid formats to specify execution of the grid point weight generator (GPWG) by the user. A positive value references a grid point of the structural model. A value of zero indicates the origin of the basic coordinate system.
GRDSET	IB	Grid point default definition card.
GRID	IB	Grid point definition card.
Grid Point	PH	A point in Euclidean 3 dimensional space defined on a GRID bulk data card. A grid point defines 6 degrees of freedom, 3 translational and 3 rotational.
GRID POINTS	IC	Used in set definition for structure plots.
GRIDB	IB	Grid point definition card for hydroelastic model.
GRIDF	IB	Grid point definition card for axisymmetric fluid cavity.
GRIDS	IB	Grid point definition card for slotted acoustic cavity.
GTKA	DBM	Aerodynamic transformation matrix - k-set to a-set.
HARMONICS	IC	Controls number of harmonics output in axisymmetric shell problems and hydroelastic problems.
HB2DD	DBM	$[B_{dd}^2]$ - Partition of heat capacity matrix.
HB2PP	DBM	$[B_{pp}^2]$ - Partition of heat capacity matrix.
HBAA	DBM	$[B_{aa}]$ - Partition of heat capacity matrix.
HBDD	DBM	$[B_{dd}]$ - Partition of heat capacity matrix.
HBFF	DBM	$[B_{ff}]$ - Partition of heat capacity matrix.
HBGG	DBM	$[B_{gg}]$ - Heat capacity matrix.
HBNN	DBM	$[B_{nn}]$ - Partition of heat capacity matrix.
HDLT	DBT	Dynamic loads table for heat transfer analysis.
Header record	PH	Initial record of a data block. Typically a header record contains only 2 BCD words, the alphanumeric name of the data block.

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HEAT	IA	Selects heat transfer analysis on APProach card.
HFREQ	P	High frequency limit for modal formulation of dynamics problems (D-10 thru D-12).
HK2DD	DBM	$[K_{dd}^2]$ - Partition of heat conductivity matrix.
HK2PP	DBM	$[K_{pp}^2]$ - Partition of heat conductivity matrix.
HKAA	DBM	$[K_{aa}]$ - Partition of heat conductivity matrix.
HKDD	DBM	$[K_{dd}]$ - Partition of heat conductivity matrix.
HKFF	DBM	$[K_{ff}]$ - Partition of heat conductivity matrix.
HKFS	DBM	$[K_{fs}]$ - Partition of heat conductivity matrix.
HKGG	DBM	$[K_{gg}]$ - Heat conductivity matrix, including estimated linear component of radiation.
HKGGX	DBM	$[K_{gg}^x]$ - Heat conductivity matrix.
HKNN	DBM	$[K_{nn}]$ - Partition of heat conductivity matrix.
HØEF1X	DBT	Heat flux output table for CHBDY elements.
HPDØ	DBM	$\{P_d^0\}$ - Partition of dynamic load vector.
HPDT	DBM	$\{P_d^t\}$ - Partition of dynamic load vector.
HPPØ	DBM	$\{P_p^0\}$ - Partition of dynamic load vector.
HPSØ	DBM	$\{P_s^0\}$ - Partition of dynamic load vector.
HQGE	DBM	$[Q_{ge}]$ - Element radiation flux matrix for heat transfer analysis.
HRAA	DBM	$[R_{aa}]$ - Partition of radiation matrix.
HRDD	DBM	$[R_{dd}]$ - Partition of radiation matrix.
HRFF	DBM	$[R_{ff}]$ - Partition of radiation matrix.
HRGG	DBM	$[R_{gg}]$ - Radiation matrix for heat transfer analysis.
HRNN	DBM	$[R_{nn}]$ - Partition of radiation matrix.
HSLT	DBT	Static heat flux table.
HTØL	DBT	List of output time steps for heat transfer.

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IC	IC	Transient analysis initial condition set selection.
ID	IA	The first card of any data deck is the identification (ID) card. The two data items on this card are BCD values.
IFP	EM	Input File Processor. The preface module which processes the sorted Bulk Data Deck and outputs various data blocks depending on the card types present in the Bulk Data Deck.
IFP1	EM	Input File Processor 1. The preface module which processes the Case Control Deck and writes the CASECC, PCDB and XYCDB data blocks.
IFP3	EM	Input File Processor 3. The preface module which processes bulk data cards for a conical shell problem.
IFP4	EM	Input File Processor 4. The preface module which processes bulk data cards for a hydroelastic problem.
IMAG	IC	Output request for real and imaginary parts of some quantity such as displacement, load, single point force of constraint element force, or stress.
IMPL	P	Parameter constant used in executive module PARAM.
INCLUDE	IC	Used in set definition for structure plots.
INERTIA	P	Used in printing rigid format error messages for Static Analysis with Inertia Relief (D-2).
INERTIA RELIEF	IA	Selects rigid format for static analysis with inertia relief.
INPT	M	A reserved NASTRAN physical unit (Tape) which must be set up by the user when used.
INPUT	FMU	Generates most of bulk data for selected academic problems.
Input Data Block	PH	A data block input to a module. An input data block must have been previously output from some module and may not be written on.
Input Data Cards	PH	The card input data to the NASTRAN system are in 3 sets, the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck.
INPUTT1	FMU	Reads data blocks from GINØ-written user tapes.
INPUTT2	FMU	Reads data blocks from FØRTRAN-written user tapes.
INPUTT3	FMX	Dummy user input module.
INPUTT4	FMX	Dummy user input module.
Internal Sort	PH	Same order as external sort except when SEQGP or SEQEP bulk data cards are used to change the sequence.
INV	IB	Inverse power eigenvalue analysis option - specified on EIGR, EIGB or EIGC cards.
IRES	P	Causes printout of residual vectors in statics rigid formats when set nonnegative via a PARAM bulk data card. (D-1, D-2, D-4, D-5, D-6).

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JUMP	EM	Unconditional transfer DMAP statement.
JUMPPLØT	P	Parameter used by structure plotter modules PLTSET and PLØT.
K2DD	DBM	$[K_{dd}^2]$ - Partition of direct input stiffness matrix.
K2DPP	DBM	$[K_{pp}^{2d}]$ - Direct input stiffness matrix for all physical points from bulk data deck.
K2PP	DBM	$[K_{pp}^2]$ - Direct input stiffness matrix for all physical points.
K2PP	IC	Direct input stiffness matrix selection.
K2PP\$	M	Indicates restart with change in direct input stiffness matrices.
K2XPP	DBM	$[K_{pp}^{2x}]$ - Direct input stiffness matrix excluding hydroelastic boundary stiffness matrix.
K4AA	DBM	$[K_{aa}^4]$ - Partition of structural damping matrix.
K4FF	DBM	$[K_{ff}^4]$ - Partition of structural damping matrix.
K4GG	DBM	$[K_{gg}^4]$ - Structural damping matrix generated by Structural Matrix Assembler.
K4NN	DBM	$[K_{nn}^4]$ - Partition of structural damping matrix.
KAA	DBM	$[K_{aa}]$ - Partition of stiffness matrix.
KBFS	DBM	$[K_{fs}^b]$ - Partition of combination of elastic stiffness matrix and differential stiffness matrix.
KBFL	DBM	$[K_{b,fl}]$ - Hydroelastic boundary stiffness matrix.
KBLL	DBM	$[K_{ll}^b]$ - Combination of elastic stiffness and differential stiffness used in static analysis with differential stiffness.
KBSS	DBM	$[K_{ss}^b]$ - Partition of combination of stiffness matrix and differential stiffness matrix.
KDAA	DBM	$[K_{aa}^d]$ - Partition of differential stiffness matrix.
KDAAM	DBM	$-[K_{aa}^d]$ - Differential stiffness matrix used in formulation of buckling problems (D-5).
KDAMP	PU	Method of computing damping.
KDD	DBM	$[K_{dd}]$ - Stiffness matrix used in direct formulation of dynamics problems (D-7 thru D-9).
KDEK2	P	Parameter indicating equivalence of KDD and K2DD.
KDEKA	P	Parameter indicating equivalence of KDD and KAA.
KDFF	DBM	$[K_{ff}^d]$ - Partition of differential stiffness matrix.
KDFS	DBM	$[K_{fs}^d]$ - Partition of differential stiffness matrix.
KDGG	DBM	$[K_{gg}^d]$ - Differential stiffness matrix prepared by Differential Stiffness Matrix Generator
KDNN	DBM	$[K_{nn}^d]$ - Partition of differential stiffness matrix.

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KDSS	DBM	$[K_{ss}^d]$ - Partition of differential stiffness matrix.
KFF	DBM	$[K_{ff}]$ - Partition of stiffness matrix.
KFS	DBM	$[K_{fs}]$ - Partition of stiffness matrix.
KGG	DBM	$[K_{gg}]$ - Stiffness matrix generated by Structural Matrix Assembler.
KGGL	DBM	$[K_{gg}^l]$ - Stiffness matrix for linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
KGGLPG	P	Purge flag for KGGL matrix. If set to -1, it implies that there are no linear elements in the structural model. (D-6).
KGGNL	DBM	$[K_{gg}^{nl}]$ - Stiffness matrix for the nonlinear elements. Used in the Piecewise Linear Analysis Rigid Format only. (D-6).
KGGSUM	DBM	Sum of KGGNL and KGGL. Used in the Piecewise Linear Analysis Rigid Format only. (D-6).
KGGX	DBM	$[K_{gg}^x]$ - Stiffness matrix excluding general elements.
KGGXL	DBM	$[K_{gg}^{xl}]$ - Stiffness matrix for linear elements (excluding general elements). Used in the Piecewise Linear Rigid Format only. (D-6).
KHH	DBM	$[K_{hh}]$ - Stiffness matrix used in modal formulation of dynamics problems (D-10 thru D-12).
KLL	DBM	$[K_{ll}]$ - Stiffness matrix used in solution of problems in static analysis (D-1, D-2, D-4, D-5, D-6).
KLR	DBM	$[K_{lr}]$ - Partition of stiffness matrix.
KNN	DBM	$[K_{nn}]$ - Partition of stiffness matrix.
KØØ	DBM	$[K_{oo}]$ - Partition of stiffness matrix.
KRR	DBM	$[K_{rr}]$ - Partition of stiffness matrix.
KSS	DBM	$[K_{ss}]$ - Partition of stiffness matrix.
KXHH	DBM	Total modal stiffness matrix - h-set.

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L	P	Parameter value used by MATGPR to print L-set matrices.
LABEL	EM	DMAP location.
LABEL	IC	Defines third line of titles to be printed on each page of printer output. Also used on plots.
LABEL	IC	Requests identification of grid points and/or elements on structure plot.
LAMA	DBT	Real eigenvalues.
LBLi	L	A label used in displacement approach rigid formats where i represents one or more characters used to form unique labels.
LBLl	DBM	$[L_{ll}^b]$ - Lower triangular factor of $[K_{ll}^b]$.
LEFT TICS	IC	Request for tic marks to be plotted on left hand edge of frame for X-Y plots.
LFREQ	P	Low frequency limit for modal formulation of dynamics problems (D-10 thru D-12).
LGPWG	L	Label used in conjunction with the Grid Point Weight Generator.
LINE	IC	Number of data lines printed per page of printer output. It should be set to 50 for 11 x 17 inch paper, and to 35 for 8 1/2 x 17 inch paper.
LLL	DBM	$[L_{ll}]$ - Lower triangular factor of $[K_{ll}]$.
LMODES	P	Number of lowest modes for modal formulation of dynamics problems (D-10 thru D-12).
L0AD	IB	Static load combination definition.
L0AD	IC	Static load set selection.
L0AD\$	M	Indicates restart with change in static load set request.
L0GARITHMIC	IC	Requests logarithmic scales for X-Y plots.
L0GPAPER	IC	Requests logarithmic paper for X-Y plots.
L00	DBM	$[L_{00}]$ - Lower triangular factor of $[K_{00}]$.
L00P1\$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
L00PBGN	L	Signifies the beginning of the Piecewise Linear Analysis Rigid Format DMAP Loop. (D-6).
L00PEND	L	Signifies the end of the Piecewise Linear Analysis Rigid Format DMAP loop. (D-6).
L00P\$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
L0WER TICS	IC	Request for tic marks to be plotted on bottom edge of frame for X-Y plots.
LUSET	P	Order of USET.
LUSETA	P	Number of degrees of freedom in the pa displacement set.
LUSETD	p	Order of USETD.

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M	P	Parameter value used by MATGPR to print M-set matrices.
M2DD	DBM	$[M_{dd}^2]$ - Partition of direct input mass matrix.
M2DPP	DBM	$[M_{pp}^{2d}]$ - Direct input mass matrix for all physical points from Bulk Data Deck.
M2PP	DBM	$[M_{pp}^2]$ - Direct input mass matrix for all physical points.
M2PP	IC	Direct input mass matrix selection.
M2PP\$	M	Indicates restart with change in direct input mass matrices.
MAA	DBM	$[M_{aa}]$ - Partition of mass matrix.
MASS	IB	Eigenvector normalization option - used on EIGR card.
MAT1	IB	Material definition card for isotropic material.
MAT2	IB	Material definition card for anisotropic material.
MAT3	IB	Material definition card for orthotropic material.
MAT4	IB	Thermal material definition card for isotropic material.
MAT5	IB	Thermal material definition card for anisotropic material.
MATGPR	FMU	Utility module for printing matrices.
MATPØØL	DBT	Grid point oriented direct input matrix data pool, output by Input File Processor and used by functional module MTRXIN.
MATPRN	FMU	Utility module for printing matrices.
MATPRT	FMU	Utility module for printing matrices.
Matrix Control Block	PH	A seven word array, the first word is a GINØ file number, and words 2 through 7 comprise a matrix trailer.
Matrix Data Block	PH	A data block is classified as a matrix if and only if it is generated by one of the NASTRAN matrix packing routines, PACK or BLDPK.
Matrix Decomposition	PH	A factorization of a matrix K so that $K = LU$ where L is a unit lower triangular matrix and U is an upper triangular matrix.
MATS1	IB	Specifies table references for stress-dependent material properties.
MATT1	IB	Specifies table references for temperature-dependent isotropic material properties.
MATT2	IB	Specifies table references for temperature-dependent anisotropic material properties.
MATT3	IB	Specifies table references for temperature-dependent orthotropic material properties.
MATT4	IB	Specifies table references for temperature-dependent isotropic, thermal material properties.

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MATT5	IB	Specifies table references for temperature-dependent, anisotropic, thermal material properties.
MAX	IB	Eigenvector normalization option - used on EIGR, EIGB and EIGC cards.
MAXIMUM DEFØRMATION	IC	Indicates scale for deformed structure plots.
MAXIT	P	Limits maximum number of iterations in nonlinear heat transfer analysis.
MAXLINES	IC	Maximum printer output line count - default value is 20000.
MCE1	FMS	Multipoint Constraint Eliminator - part 1.
MCE2	FMS	Multipoint Constraint Eliminator - part 2.
MDD	DBM	$[M_{dd}]$ - Mass matrix used in direct formulation of dynamics problems (D-7 thru D-9).
MDEMA	P	Parameter indicating equivalence of MDD and MAA.
MDLCEAD	P	Used in printing rigid format error messages for modal complex eigenvalue analysis (D-10).
MDLFRRD	P	Used in printing rigid format error messages for modal frequency response (D-11).
MDLTRD	P	Used in printing rigid format error messages for modal transient response (D-12).
MERGE	FMM	Matrix merge functional module.
METHØD	IC	Selects method for real eigenvalue analysis.
METHØD\$	M	Indicates restart with change in eigenvalue extraction procedures.
MFF	DBM	$[M_{ff}]$ - Partition of mass matrix.
MGG	DBM	$[M_{gg}]$ - Mass matrix generated by Structural Matrix Assembler.
MHH	DBM	$[M_{hh}]$ - Mass matrix used in modal formulation of dynamics problems (D-10 thru D-12).
MI	DBM	$[m]$ - Modal mass matrix.
MKAERØ1	IB	Provides table of Mach numbers and reduced frequencies (k).
MKAERØ2	IB	Provides list of Mach numbers (m) and reduced frequencies (k).
MLL	DBM	$[M_{ll}]$ - Partition of mass matrix.
MLR	DBM	$[M_{lr}]$ - Partition of mass matrix.
MNN	DBM	$[M_{nn}]$ - Partition of mass matrix.
MØA	DBM	$[\bar{M}_{oa}]$ - Partition of mass matrix.
MØDA	FMX	This module is reserved for user implementation.
MØDACC	FMS	Mode Acceleration Output Reduction Module.

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MØDAL	IC	Requests structure plots of mode shapes.
MØDAL	P	Indicates modal as opposed to direct formulation of dynamics problems. (D-10 thru D-12).
MØDAL CØMPLEX EIGENVALUES	IA	Selects rigid format for modal complex eigenvalue analysis.
MØDAL FREQUENCY RESPØNSE	IA	Selects rigid format for modal frequency and random response.
MØDAL TRANSIENT RESPØNSE	IA	Selects rigid format for modal transient response.
MØDB	FMX	This module is reserved for user implementation.
MØDC	FMX	This module is reserved for user implementation.
MØDEL	IC	Indicates model number of structure plotter.
MØDES	IA	Selects rigid format for normal mode analysis.
MØDES	IC	Duplicates output requests for eigenvalue problems.
MØDES	P	Used in printing rigid format error messages for normal modes analysis (D-3).

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Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution by changing the rigid format and/or selected input data.
Module	PH	A logical group of subroutines which performs a defined function.
MØMAX	IB	Conical shell moment definition card.
MØMENT	IB	Static moment load definition (vector).
MØMENT1	IB	Static moment load definition (magnitude and two grid points).
MØMENT2	IB	Static moment load definition (magnitude and four grid points).
MØØ	DBM	$[M_{\text{ØØ}}]$ - Partition of mass matrix.
MPC	IB	Multipoint constraint definition.
MPC	IC	Multipoint constraint set request.
MPC\$	M	Indicates restart with change in multipoint constraints.
MPCADD	IB	Multipoint constraint set definition.
MPCAX	IB	Conical shell multipoint constraint definition.
MPCF1	P	No multipoint constraints.
MPCF2	P	No change in multipoint constraints for loop.
MPL	PH	Module properties list. The MPL defines each DMAP module's name, the number of input, output and scratch files required and the parameter list. It is used by the preface module XGPI to generate the ØSCAR.
MPT	DBT	Material Properties Table - output by Input File Processor.
MPY	M	Parameter constant used in executive module PARAM.
MPYAD	FMM	Performs multiply-add matrix operation.
MR	DBM	$[m_r]$ - Rigid body mass matrix.
MRR	DBM	$[M_{rr}]$ - Partition of mass matrix.
MTRXIN	FMS	Selects direct input matrices for current loop in dynamics problems (D-7 thru D-12).
MX	IC	Indicates negative x-axis direction for structure plot.
MXHH	DBM	Total modal mass matrix - h-set.
MY	IC	Indicates negative y-axis direction for structure plot.
MZ	IC	Indicates negative z-axis direction for structure plot.

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N	M	Used in parameter section of DMAP statement. Indicates that parameter may not be given an initial value with a PARAM bulk data card.
N	P	Parameter value used by MATGPR to print N-set matrices.
NASTPLT	IC	Requests NASTRAN general purpose plotter.
NASTRAN	M	Acronym for NAsa STRuctural ANalysis program.
NASTRAN Data Deck	PH	The composite deck consisting of the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck. This deck, when preceded by any necessary operating system control cards, constitutes the complete card input for a NASTRAN run (PM-5).
NE	P	Parameter value used by MATGPR to print out NE-set matrices.
NEIGV	P	Number of real eigenvalues found.
NEVER	P	Set to +1 by a DMAP PARAM statement in the Piecewise Linear Analysis Rigid Format (D-6).
New Problem Tape	PH	See Problem Tape.
NJ	P	Number of degrees of freedom in the j displacement set.
NK	P	Number of degrees of freedom in the k displacement set.
NLFT	DBT	Nonlinear function table.
NLLØAD	IC	Requests nonlinear load output for transient problems.
NØ	IA	Option used on CHKPNT card, indicates that no checkpoint is desired.
NØA	P	Indicates no constraints applied to structural model.
NØABFL	P	No fluid-structure interface in a hydroelastic problem.
NØB2PP	P	No direct input damping matrix.
NØBGG	P	No viscous damping matrix (D-7 thru D-9).
NØCSTM	P	No Coordinate System Transformation Matrices.
NØD	P	No output request that is limited to independent degrees of freedom.
NØDJE	PU	Positive value selects D1JE and D2JE from INPUTT2.
NØDLT	P	No Dynamic Loads Table.
NØEED	P	No Eigenvalue Extraction Data
NØELMT	P	No elements are defined.
NØFL	P	No fluid-structure interface and no fluid gravity in a hydroelastic problem.
NØFRL	P	No Frequency Response List.
NØGENEL	P	No general elements.

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NØGPDT	P	No Grid Point Definition Table.
NØGRAV	P	No gravity loads.
NØK2DPP	P	No direct input stiffness matrix from Bulk Data Deck.
NØK2PP	P	No direct input stiffness matrices.
NØK4GG	P	No structural damping matrix.
NØKBFL	P	No fluid gravity or structural interface in a hydroelastic problem.
NØL	P	No independent degrees of freedom.
NØLIN1	IB	Nonlinear transient dynamic load set definition card.
NØLIN2	IB	Nonlinear transient dynamic load set definition card.
NØLIN3	IB	Nonlinear transient dynamic load set definition card.
NØLIN4	IB	Nonlinear transient dynamic load set definition card.
NØLØØP\$	M	Indicates restart of problem without DMAP loop. (PM-4.3.7.1).
NØM2DPP	P	No direct input mass matrix from Bulk Data Deck.
NØM2PP	P	No direct input mass matrices.
NØMGG	P	If functional module SMA2 generates a zero mass matrix, NØMGG is set to -1. Otherwise, it is set to +1.
NØMØD	P	Mode acceleration data recovery not requested.
NØNCUP	P	Indicates diagonal MHH, BHH, and KHH allowing uncoupled solution in TRD and FRRD.
NØNE	IC	Override for output and bulk data deck echo requests.
NØNLFT	P	No nonlinear function table.
NØNLINER	IC	Selects nonlinear load for transient problems.
NØNLSTR	P	No stress output request for nonlinear elements (D-6).
NØP	M	Parameter constant used in executive module PARAM.
NØP	P	No output request involving dependent degrees of freedom or stresses.
NØPSDL	P	No Power Spectral Density List.
NØRMAL MØDES	IA	Selects rigid format for normal mode analysis.
NØSET	P	No dependent coordinates.
NØSIMP	P	No structural elements are defined.
NØSØRT2	P	No request for output sorted by point number or element number.
NØSR	P	No single-point constraints or free body supports.
NØT	M	Parameter constant used in utility module PARAM.

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NØTFL	P	No Transfer Function List.
NØTRL	P	No Transient Response List.
NØUE	P	No extra points introduced for dynamic analysis.
NØXYCBD	P	-1 indicates no XY output requests.
NPLALIM	P	Set by module PLAl as the Piecewise Linear Analysis Rigid Format DMAP loop counter. (D-6)
NPTP	M	New Problem Tape - a reserved NASTRAN physical unit (TAPE) which must be set up by the user when used.
NSIL	P	Order of SIL table.
NSKIP	P	Locate current boundary conditions in Case Control.
NUMF	M	New User Master File - used only when operating NASTRAN as a user master file editor. (See UMFEDIT). A reserved NASTRAN physical unit (tape) which must be set up by the user when used.
NVECTS	P	Number of eigenvectors found.

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Ø	P	Parameter value used by MATGPR to print Ø-set matrices.
ØBEF1	DBT	Element force output table (D-5).
ØBES1	DBT	Element stress output table (D-5).
ØBQG1	DBT	Forces of single point constraint output table (D-5).
ØCEIGS	DBT	Complex eigenvalue summary table (D-7, D-10).
ØCPHIP	DBT	Complex eigenvector output table (D-7, D-10).
ØEF1	DBT	Element force output table (D-1, D-2, D-4, D-5, D-6).
ØEF2	DBT	Element force output table - SØRT2 (D-9, D-12).
ØEFB1	DBT	Element force output table (D-4).
ØEFC1	DBT	Element force output table - complex (D-7, D-8, D-10, D-11).
ØEFC2	DBT	Element force output table - complex - SØRT2 (D-8, D-11).
ØEIGS	DBT	Real Eigenvalue summary output table (D-3, D-5).
ØES1	DBT	Element stress output table (D-1, D-2, D-4, D-5, D-6).
ØES2	DBT	Element stress output table - SØRT2 (D-9, D-12).
ØESB1	DBT	Element stress output table (D-4).
ØESC1	DBT	Element stress output table - complex (D-7, D-8, D-10, D-11).
ØESC2	DBT	Element stress output table - complex - SØRT2 (D-8, D-11).
ØFP	FMS	Output File Processor.
ØFREQ	IC	Output Frequency set.
ØFREQUENCY	IC	Selects from the solution set of frequencies a subset for output requests.
ØGPST	DBT	Grid point singularity output table.
ØGPWG	DBT	Grid point weight generator output table.
Old Problem Tape	PH	See Problem Tape.
ØLOAD	IC	Request for output of external load vector.
ØMIT	IB	Omitted coordinate definition card.
ØMIT	P	Indicates no omitted coordinates.
ØMIT1	IB	Omitted coordinate definition card.
ØMITAX	IB	Omitted coordinate definition card for conical shell problems.
ØNLES	DBT	Output table for nonlinear element stresses (D-6).
Open Core	PH	A contiguous block of working storage defined by a labeled common block, whose length is a variable determined by the NASTRAN executive routine CØRSZ.
ØPG1	DBT	Static load output table (D-1, D-2, D-4, D-5, D-6).

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ØPHID	DBT	Output table for complex eigenvectors - solution set (D-7).
ØPHIG	DBT	Eigenvector output table (D-3, D-5).
ØPHIH	DBT	Output table for complex eigenvectors - solution set (D-10).
ØPNL1	DBT	Output table for nonlinear loads - solution set, SØRT1 (D-9, D-12).
ØPNL2	DBT	Output table for nonlinear loads - solution set, SØRT2 (D-9, D-12).
ØPP1	DBT	Dynamic load output table (D-9, D-12).
ØPP2	DBT	Dynamic load output table - SØRT2 (D-9, D-12).
ØPPC1	DBT	Dynamic load output table - SØRT1, complex (D-8, D-11).
ØPPC2	DBT	Dynamic load output table - SØRT2, complex (D-8, D-11).
ØPTP	M	Old Problem Tape - a reserved NASTRAN physical unit (tape) which must be set up by the user when used.
ØQBG1	DBT	Forces of single-point constraint output table (D-4).
ØQG1	DBT	Single-point constraint force output table (D-1, D-2, D-4, D-5, D-6).
ØQP1	DBT	Single-point constraint force output table SØRT1 (D-9, D-12).
ØQP2	DBT	Single-point constraint force output table SØRT2 (D-9, D-12).
ØQPC1	DBT	Single-point constraint force output table - complex, SØRT1 (D-7, D-8, D-10, D-11).
ØQPC2	DBT	Single-point constraint force output table - complex, SØRT2 (D-7, D-8, D-10, D-11).
ØR	M	Parameter constant used in executive module PARAM.
ØRIGIN	IC	Locates origin for structure plot.
ØRTHØGRAPHIC	IC	Specifies orthographic projection for structure plot.
ØSCAR	PH	Operation sequence control array. Executive table residing on the Data Pool File which contains the sequence of operations to be executed for a problem solution. The ØSCAR is an expansion of a DMAP sequence, either input by the user or extracted from a rigid format, in internal format.
ØUBGV1	DBT	Displacement vector output table (D-4).
ØUDV1	DBT	Displacement vector output table - solution set, SØRT1 (D-9).
ØUDV2	DBT	Displacement vector output table - solution set, SØRT2 (D-9).
ØUDVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-8, D-11).

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ØUDVC2	DBT	Displacement vector output table - solution set, SØRT2, complex (D-8, D-11).
ØUGV1	DBT	Displacement output table (D-1, D-2, D-4, D-5, D-6).
ØUHV1	DBT	Displacement vector output table - solution set, SØRT1 (D-12).
ØUHV2	DBT	Displacement vector output table - solution set, SØRT2 (D-12).
ØUHVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-11).
ØUHVC2	DBT	Displacement vector output table - solution set, SØRT2 complex (D-11).
ØUPV1	DBT	Displacement vector output table - SØRT1 (D-9, D-12).
ØUPV2	DBT	Displacement vector output table - SØRT2 (D-9, D-12).
ØUPVC1	DBT	Displacement vector output table - complex, SØRT1 (D-8, D-11).
ØUPVC2	DBT	Displacement vector output table - complex, SØRT2 (D-8, D-11).
ØUTPUT	FMX	This module is reserved for user implementation.
ØUTPUT	IC	Marks beginning of printer output request packet - optional.
Output Data Block	PH	A data block output from a module. A data block may be output from one and only one module. Having been output, it may be used as an input data block as many times as necessary.
ØUTPUT1	FMU	Writes data blocks on GINØ-written user tapes.
ØUTPUT2	FMU	Writes data blocks on FØRTRAN-written user tapes.
ØUTPUT3	FMU	Punches matrices on DMI cards.
ØUTPUT4	FMX	Dummy user output module.
ØUTPUT(PLØT)	IC	Marks beginning of output request packet for structure plots.
ØUTPUT(XYØUT)	IC	Marks beginning of output request packet for X-Y plots.
ØUTPUT(XYPLØT)	IC	Marks beginning of output request packet for X-Y plots.
ØVG	DBT	Output aeroelastic curve requests (V-g or V-f).

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P	P	Parameter value used in MATGPR to print P-set matrices.
Packed Format	PH	A matrix is said to be in packed format if only the nonzero elements of the matrix are written.
PAPER SIZE	IC	Selects paper size for structure plots using table plotters.
PARAM	FMU	Performs specified operations on DMAP parameters.
PARAM	IB	Parameter definition card.
Parameter	PH	A FORTRAN variable communicated to a DMAP module by the NASTRAN Executive System through blank common. A parameter's position in the DMAP calling sequence to a module corresponds to the position of the parameter in blank common at module execution time.
PARAML	FMU	Selects parameters from a user input matrix or table.
PARAMR	FMU	Performs specified operations on real or complex parameters.
PARTN	FMM	Matrix partitioning functional module.
PBAR	IB	Bar property definition card.
PBL	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PBS	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PCDB	DBT	Plot control data block (table for use with structure plotter functional module PLTSET).
PCONEAX	IB	Conical shell element property definition card.
PDAMP	IB	Scalar damper property definition card.
PDF	DBM	Dynamic load matrix for frequency analysis.
PDT	DBM	Linear dynamic load matrix for transient analysis.
PDUMi	IB	Property definition card for dummy elements 1 through 9.
PELAS	IB	Scalar elastic property definition card.
PEN	IC	Selects pen size for structure plots using table plotters.
PENSIZ	IC	Selects pen size for X-Y plots using table plotters.
PERSPECTIVE	IC	Specifies perspective projection for structure plots.
PFILE	P	Parameter used by PLOT module.
PG	DBM	Incremental load vector used in Piecewise Linear Analysis (D-6).
PG	DBM	Statics load vector generated by SSG1.
PG1	DBM	Static load vector for Piecewise Linear Analysis (D-6).
PGG	DBM	Appended static load vector (D-1, D-2).

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PGV1	DBM	Matrix of successive sums of incremental load vectors used only in Piecewise Linear Analysis Rigid Format (D-6).
PHASE	IC	Requests magnitude and phase form of complex quantities.
PHBDY	IB	Boundary element property definition card for heat transfer analysis.
PHIA	DBM	$[\phi_a]$ - Real eigenvectors - solution set.
PHID	DBM	$[\phi_d]$ - Complex eigenvectors - solution set, direct formulation.
PHIDH	DBM	$[\phi_{dh}]$ - Transformation matrix between modal and physical coordinates.

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PHIG	DBM	$[\phi_g]$ - Real eigenvectors.
PHIH	DBM	$[\phi_h]$ - Complex eigenvectors - solution set, modal formulation.
PHIHL	DBM	Appended complex mode shapes - h-set.
Physical Points	PH	Grid points and extra scalar points introduced for dynamic analysis.
PIECEWISE LINEAR	IA	Selects rigid format for piecewise linear analysis.
Pivot Point	PH	The first word of each record of the GPCT and ECPT data blocks is called the pivot point.
PL	DBM	$\{P_\rho\}$ - Partition of load vector.
PLA	P	Used in printing rigid format error messages for Piecewise Linear Analysis (D-6).
PLA1	FMS	Piecewise Linear Analysis - phase 1.
PLA2	FMS	Piecewise Linear Analysis - phase 2.
PLA3	FMS	Piecewise Linear Analysis - phase 3.
PLA4	FMS	Piecewise Linear Analysis - phase 4.
PLACØUNT	P	Loop counter in Piecewise Linear Analysis (D-6).
PLALBL2A	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL3	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL4	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLCØEFFICIENT	IC	Selects the coefficient set for Piecewise Linear Analysis problems.
PLFACT	IB	Piecewise Linear Analysis factor definition card.
PLI	DBM	$\{P_\rho^i\}$ - Partition of inertia relief load vector.
PLØAD	IB	Pressure load definition (D-1, D-2, D-4, D-5, D-6).
PLØAD2	IB	Element pressure loading for two-dimensional elements (D-1, D-2, D-4, D-5, D-6).
PLØT	FMS	Structure plot generator.
PLØT	IC	Execution card for structure plotter.
PLØT\$	M	Indicates restart with a structure plot request.
Plot Tapes	PH	Magnetic tapes containing NASTRAN generated data to drive offline plotters. PLT1 is the name of the BCD plot tape, used by the EAI 3500, and PLT2 is the name of binary plot tape, used by the SC-4020.
PLØTEL	IB	Plot element definition card used to define convenient reference lines in structure plots.
PLØTTER	IC	Used to select one of several available plotters for structure plotter.

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PLØTX1	DBT	Messages from plot module concerning action taken by the structure plotter in processing undeformed structure plots.
PLØTX2	DBT	Messages from plot module concerning action taken by the structure plotter in processing deformed structure plots.
PLSETNØ	P	Set number on a PLFACT bulk data card chosen by the user in his case control deck. Used only in Piecewise Linear Analysis (D-6).
PLT1	M	A reserved NASTRAN physical unit (tape) which must be set up by the user when used - see Plot Tapes.
PLT2	M	A reserved NASTRAN physical unit (tape) which must be set up by the user when used - see Plot Tapes.
PLTFLG	P	Parameter used by PLØT module.
PLTPAR	DBT	Plot control table.
PLTSET	FMS	Plot set definition processor.
PLTSETX	DBT	Error messages for plot sets.
PLTTRAN	FMS	Prepares data blocks for acoustic analysis plots.
PLTTRAN	FMS	Transforms grid point definition tables for scalar points into a format for plotting.
PMASS	IB	Scalar mass property definition card.
PNLD	DBM	$\{P_d^n\}$ - Nonlinear loads in direct transient problem.
PNLH	DBM	$\{P_h^n\}$ - Nonlinear loads in modal transient problem.
PØ	DBM	$\{P_o\}$ - Partition of load vector.
PØI	DBM	$\{P_o^i\}$ - Partition of inertia relief load vector.
PØINT	IB	Eigenvalue analysis normalization option for eigenvectors - see EIGR, EIGC, EIGB cards.
PØINTAX	IB	Conical shell point used for data recovery.
PØØL	M	Pool tape used by file allocator.
PØUT\$	M	Indicates restart with a printer output request.
PPF	DBM	Dynamic loads for frequency response.
PPHIG	DBM	Eigenvector components used to plot deformed shape. (D-3, D-5).
PPT	DBM	Linear dynamic loads for transient analysis.
PQDMEM	IB	Quadrilateral membrane element property definition card.
PQDMEM1	IB	Isoparametric quadrilateral membrane element property definition card.
PQDMEM2	IB	Quadrilateral membrane element property definition card.

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PQDPLT	IB	Quadrilateral bending element property definition card.
PQUAD1	IB	General quadrilateral element property definition card.
PQUAD2	IB	Homogeneous quadrilateral element property definition card.
PREC	P	Precision of computer <div> IBM = 2 UNIVAC CDC = 1 </div>
Preface	PH	Executive routines which are executed prior to the execution of the first module in a DMAP sequence. The Preface consists of the executive routines necessary to generate initial NASTRAN operational data and tables. The primary Preface routines are GNFIAT, XCSA, IFP1, XSORT, IFP, IFP3, and XGPI.

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PRESAX	IB	Defines static pressure loading for the conical shell element.
PRESPT	IB	Defines a point in a hydroelastic model for output purposes.
PRESSURE	IC	Request for output of pressure and displacement vector or eigen-vector for a hydroelastic problem.
PRINT	PU	Controls printing of flutter summary.
Problem Tape	PH	A magnetic tape containing data necessary for NASTRAN problem restarts. A tape being generated is designated as the New Problem Tape (NPTP) and its content is largely controlled by the DMAP instruction CHKPNT. This same tape when used as input to a subsequent NASTRAN restart is designated as the Old Problem Tape (ØPTP).
PRØD	IB	Rod property definition card.
PRØJECTION PLANE SEPARATION	IC	Separation of observer and projection plane for structure plots.
PRTMSG	FMS	Message generator.
PRTPARM	FMU	Prints DMAP diagnostic messages and parameter values.
PS	DBM	{P _S } - Partition of static load vector.
PSDF	DBM	Power Spectral Density Function table.
PSDF	IC	Request for output of Power Spectral Density Function in Random Analysis (D-9, D-11).
PSDL	DBT	Power Spectral Density List.
Pseudo Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution but only affecting output data.
PSF	DBM	Partition of load vector for transient analysis.
PSHEAR	IB	Shear panel property definition card.
PST	DBM	Partition of linear load vector for transient analysis.
PTØRDRG	IB	Toroidal ring property definition card.
PRTBSC	IB	Basic bending triangular element property definition card.
PTRIA1	IB	General triangular element property definition card.
PTRIA2	IB	Homogeneous triangular element property definition card.
PTRMEM	IB	Triangular membrane element property definition card.
PTRPLT	IB	Triangular bending element property definition card.
PTUBE	IB	Tube property definition card.
PTWIST	IB	Twist panel property definition card.
PUBGV1	DBT	Displacement vector components used to plot deformed shape (D-4, D-5).
PUGV	DBT	Displacement vector components used to plot deformed shape (D-1, D-2).

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PUGV1	DBT	Displacement components used to plot deformed shape (D-6).
PUNCH	IC	Output media request (PRINT or PUNCH).
PURGE	EM	DMAP statement which causes conditional purging of data blocks.
Purge	PH	A data block is said to be purged when it is flagged in the FIAT so that it will not be allocated to a physical file and so that modules attempting to access it will be signaled.
PVISC	IB	Viscous element property definition card.
PVT	PH	Parameter value table. The PVT contains BCD names and values of all parameters input by means of PARAM bulk data cards. It is generated by the preface module IFP and is written on the Problem Tape.
P1	PU	INPUTT2 rewind option.
P2	PU	INPUTT2 unit number.
P3	PU	INPUTT2 tape ID.
QBDY1	IB	Defines uniform heat flux into HBDY elements.
QBDY2	IB	Defines grid point heat flux into HBDY elements.
QBG	DBM	Single point forces of constraint in the Differential Stiffness Rigid Format (D-4).
QDMEM	IC	Requests structure plot for all QDMEM elements.
QDMEM1	IC	Requests structure plot for all QDMEM1 elements.
QDMEM2	IC	Requests structure plot for all QDMEM2 elements.
QDPLT	IC	Requests structure plot for all QDPLT elements.
QG	DBM	Constraint forces for all grid points.
QHBDY	IB	Defines thermal load for steady-state heat conduction.
QHHL	DBML	Aerodynamic matrix list - h-set.
QJHL	DBML	Aerodynamic transformation matrix between h and j sets.
QP	DBM	Constraint forces for all physical points.
QPC	DBM	Complex single point forces of constraint for all physical points.
QR	DBM	{ q_r } - Determinant support forces.
QS	DBM	{ q_s } - Single-point constraint forces.
QUAD1	IC	Requests structure plot for all QUAD1 elements.
QUAD2	IC	Requests structure plot for all QUAD2 elements.
QVECT	IB	Defines thermal vector flux from distant source.
QVØL	IB	Defines volume heat generation.

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R	P	Parameter value used by MATGPR to print R-set matrices.
R1	IC	Request for X-Y plot of the first rotational component (UM-4.2).
R1IP	IC	Request for X-Y plot of the first rotational component - imaginary and phase angle (UM-4.2).
R1RM	IC	Request for X-Y plot of the first rotational component - real and magnitude (UM-4.2).
R2	IC	Request for X-Y plot of the second rotational component (UM-4.2).
R2IP	IC	Request for X-Y plot of the second rotational component - imaginary and phase angle (UM-4.2).
R2RM	IC	Request for X-Y plot of the second rotational component - real and magnitude (UM-4.2).
R3	IC	Request for X-Y plot of the third rotational component (UM-4.2).
R3IP	IC	Request for X-Y plot of the third rotational component - imaginary and phase angle (UM-4.2).
R3RM	IC	Request for X-Y plot of the third rotational component - real and magnitude (UM-4.2).
RADLIN	P	Controls linearization of radiation effects in transient heat transfer analysis.
RADLST	IB	List of radiation areas.
RADMTX	IB	Radiation exchange coefficients.
RANDØM	IC	Selects the RANDPS and RANDT cards to be used in random analysis.
RANDØM	FMS	Random response solution generator.
RANDPS	IB	Power spectral density specification.
RANDT1	IB	Autocorrelation function time lag.
RANDT2	IB	Autocorrelation function time lag.
RBMG1	FMS	Rigid body matrix generator - part 1.
RBMG2	FMS	Rigid body matrix generator - part 2.
RBMG3	FMS	Rigid body matrix generator - part 3.
RBMG4	FMS	Rigid body matrix generator - part 4.
READ	FMS	Real Eigenvalue Analysis - Displacement.
REAL	IC	Requests real and imaginary form of complex quantities.
REAL EIGENVALUES	IA	Selects rigid format for normal mode analysis.
REEL	IA	Term appearing on the checkpoint dictionary cards indicating the physical reel on which a data block appears.

NASTRAN DICTIONARY

Reentry Point	PH	The point in the DMAP sequence at which a problem terminated and hence the point at which it can be restarted (see Restart).
REGION	IC	Specifies portion of frame to be used for structure plot.
REIG	P	Parameter used in SDR2 to indicate Normal Mode Analysis (D-3).
REPCASE	IC	Allows another output request for the previous subcase (D-1, D-2).
REPEAT	P	Controls looping in Static Analysis (D-1, D-2).
REPEATD	P	Controls looping in Static Analysis with Differential Stiffness (D-4).
REPEATE	P	Controls looping in Complex Eigenvalue Analysis (D-7, D-10).
REPEATF	P	Controls looping in Frequency Response Analysis (D-8, D-11).
REPEATT	P	Controls looping in Transient Response Analysis (D-9, D-12).
REPT	EM	DMAP statement to conditionally repeat a loop.
RESPONSE	J'	Request for X-Y plot of any response outputs from transient or frequency response analysis (D-8, D-9, D-11, D-12).
RESTART	IA	First control card of checkpoint dictionary. Contains identification of checkpoint tape.
Restart	PH	Initiating a NASTRAN problem solution at a place other than its logical beginning by utilizing an Old Problem Tape created during a previous run.
RFORCE	IB	Rotational force definition card.
RFORCE\$	M	Indicates restart with change in rotational force.
RG	DBM	Multipoint constraint equations.
RIGHT TICS	IC	Request for tic marks to be plotted on right hand edge of frame for X-Y plots.
Rigid Format	PH	A fixed prestored DMAP sequence and its associated restart tables which perform a specific problem solution.
Rigid Format Switch	PH	A type of restart (see Restart) in which the problem is changed from one Rigid Format to another.
RINGAX	IB	Conical shell ring definition card.
RINGFL	IB	Hydroelastic axisymmetric point definition card.
RL0AD1	IB	Frequency response load set definition.
RL0AD2	IB	Frequency response load set definition.
RMG	FMH	Radiation matrix generator - generates $[R_{gg}]$.
R0D	IC	Requests structure plot for all R0D elements.
RUBLV	DBM	Residual vector - Differential Stiffness Rigid Format (D-4).

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RULV	DBM	Residual vector for independent degrees of freedom.
RUØV	DBM	Residual vector for omitted degrees of freedom.
RXY	IC	Requests vector sum of X and Y deformation components for structure plot.
RXYZ	IC	Requests vector sum of X, Y and Z deformation components for structure plot.
RXZ	IC	Requests vector sum of X and Z deformation components for structure plot.
RYZ	IC	Requests vector sum of Y and Z deformation components for structure plot.

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S	P	Parameter value used by MATGPR to print S-set matrices.
SACCE	IC	Abbreviated form of SACCELERATION.
SACCELERATION	IC	Output request for solution set acceleration vector. (UM-2.3, 4.2)
SAVE	EM	DMAP statement which causes current value of parameter to be saved.
SAVE	M	Save data block for possible looping in DMAP sequence (see FILE).
SC	IC	Selects SC 4020 plotter.
Scalar Point	PH	A point which is defined on an SPPOINT, CELAS1, CELAS2, CELAS3, CELAS4, CMASS1, CMASS2, CMASS3, CMASS4, CDAMP1, CDAMP2, CDAMP3, or CDAMP4 bulk data card. A scalar point has no geometrical coordinates and defines only one degree of freedom of the model.
SCALE	IC	Selects scale for structure plot.
SCE1	FMS	Single-point Constraint Eliminator.
SDAMP	IC	Modal structural damping table selection.
SDAMP\$	M	Indicates restart with change in modal damping.
SDAMPING	IC	Selects table which defines damping as a function of frequency in modal formulation problems.
SDISP	IC	Abbreviated form of SDISPLACEMENT.
SDISPLACEMENT	IC	Output request for solution set displacement vector. (UM-2.3, 4.2)
SDR1	FMS	Stress Data Recovery - part 1.
SDR2	FMS	Stress Data Recovery - part 2.
SDR3	FMS	Stress Data Recovery - part 3.
SDRHT	FMH	Heat flux data recovery.
SECTAX	IB	Defines conical shell sector for data recovery.
SEEMAT	FMU	Prints pictorial representation of matrix showing location of nonzero elements.
SEM1	M	The NASTRAN Preface.
SEQEP	IB	Extra point resequencing.
SEQGP	IB	Grid or scalar point resequencing.
SET	IC	Definition of a set of elements, grid and/or scalar and/or extra points, frequencies, or times to be used in selecting output.
SET1	IB	Defines a set of structural grid points by a list.
SET2	IB	Defines a set of structural grid points by aerodynamic macro elements.
SETVAL	FMU	Parameter value initiator.
SHEAR	IC	Requests structure plot for all shear panel elements.

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SIGMA	P	Defines Stefan-Boltzmann constant in heat transfer analysis.
SIL	DBT	Scalar Index List for all grid points.
SILA	DBT	Scalar Index List - Aerodynamics.
SILD	DBT	Scalar Index List for all grid points and extra scalar points introduced for dynamic analysis.
SILGA	DBT	Scalar Index List - Aerodynamic boxes only.
SINE	IC	Conical shell request for sine set boundary conditions.
SINGLE	P	No single-point constraints.
SKIP BETWEEN FRAMES	IC	Request to insert blank frames on SC 4020 plotter for X-Y plots.
SKJ	DBM	Integration matrix.
SKPMGG	P	Parameter used in statics to control execution of functional module SMA2.
SLBDY	IB	Defines list of points on interface between axisymmetric fluid and radial slots.
SLØAD	IB	Scalar point load definition.
SLT	DBT	Static Loads Table.
SMA1	FMS	Structural Matrix Assembler - phase 1 - generates stiffness matrix $[K_{gg}]$ and structural damping matrix $[K_{gg}^4]$.
SMA2	FMS	Structural Matrix Assembler - phase 2 - generates mass matrix $[M_{gg}]$ and viscous damping matrix $[B_{gg}]$.
SMA3	FMS	Structural Matrix Assembler - phase 3 - add general element contributions to the stiffness matrix $[K_{gg}]$.
SMP1	FMS	Structural Matrix Partitioner - part 1.
SMP2	FMS	Structural Matrix Partitioner - part 2.
SMPYAD	FMM	Performs multiply-add matrix operation for up to five multiplications and one addition.
SØL	IA	Specifies which rigid format solution is to be used when APP is DISPLACEMENT.
Solution Points	PH	Points used in the formulation of the general K system.
SØLVE	FMM	Solves a set of linear algebraic equations.
SØRT1	IC	Output is sorted by frequency or time and then by external ID.
SØRT2	IC	Output is sorted by external ID and then by frequency or time.
SØRT3	M	Output is sorted by individual item or component and then by frequency or time.
SPC	IB	Single-point constraint and enforced deformation definition.

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SPC	IC	Single-point constraint set selection.
SPC\$	M	Indicates restart with change in single-point constraint set selection.
SPC1	IB	Single-point constraint definition.
SPCADD	IB	Single-point constraint set combination definition.
SPCAX	IB	Conical shell single-point constraint definition.
SPCF	IC	Abbreviated form of SPCFORCE.
SPCFORCE	IC	Single-point constraint force output request. (UM-2.3,4.2)
Spill	PH	Secondary storage devices are used because there is insufficient main storage to perform a matrix calculation or a data processing operation.
SPLINE	DBT	Splining Data Table.
SPLINE1	IB	Defines surface spline.
SPLINE2	IB	Defines beam spline.
SPØINT	IB	Scalar point definition card.
SSG1	FMS	Static Solution Generator - part 1.
SSG2	FMS	Static Solution Generator - part 2.
SSG3	FMS	Static Solution Generator - part 3.
SSG4	FMS	Static Solution Generator - part 4.
SSGHT	FMH	Solution generator for nonlinear heat transfer analysis.
STATIC	IC	Requests deformed structure plot for problem in Static Analysis.
STATICS	IA	Selects statics rigid format for heat transfer or structural analysis.
STATICS	P	Parameter used in SDR2 to indicate Static Analysis.
STEADY STATE	IA	Selects rigid format for nonlinear static heat transfer analysis.
STEREØSCØPIC	IC	Requests stereoscopic projections for structure plot.
STRESS	IC	Element stress output request. (UM-2.3, 4.2)
Structural Element	PH	One of the finite elements used to represent a part of a structure.
SUBCASE	IC	Subcase definition.
SUBCØM	IC	This subcase is a linear combination of previous subcases.
SUBSEQ	IC	Specifies coefficients for SUBCØM subcases.
SUBTITLE	IC	Output labeling data for printer output.
SUPAX	IB	Fictitious support for conical shell problem.

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SUPØRT	IB	Fictitious support definition card.
SVECTØR	IC	Request for output of eigenvectors in the solution set (D-7, D-10) (UM-2.3, 4.2).
SVELØ	IC	Abbreviated form of SVELØCITY.
SVELØCITY	IC	Requests velocity output for solution set. (UM-2.3, 4.2)
SYM	IC	Symmetry subcase delimiter card.
SYMBØLS	IC	Requests symbols at grid points on structure plot.
SYMCØM	IC	Assembly of symmetry subcase delimiter card.
SYMSEQ	IC	Assembly value of symmetry combination card.

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T1	IC	Request for X-Y plot of the first translational component (UM-4.2).
T1IP	IC	Request for X-Y plot of the first translational component - imaginary and phase angle (UM-4.2).
T1RM	IC	Request for X-Y plot of the first translational component - real and magnitude (UM-4.2).
T2	IC	Request for X-Y plot of the second translational component (UM-4.2).
T2IP	IC	Request for X-Y plot of the second translational component - imaginary and phase angle (UM-4.2).
T2RM	IC	Request for X-Y plot of the second translational component - real and magnitude (UM-4.2).
T3	IC	Request for X-Y plot of the third translational component (UM-4.2).
T3IP	IC	Request for X-Y plot of the third translational component - imaginary and phase angle (UM-4.2).
T3RM	IC	Request for X-Y plot of the third translational component - real and magnitude (UM-4.2).
TA1	FMS	Table Assembler.
TABDMP1	IB	Tabular structural damping function for modal formulation (D-10, D-11, D-12).
Table Data Block	PH	A data block which is in tabular form rather than matrix form.
TABLED1	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED2	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED3	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED4	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLEM1	IB	Material property tabular function.
TABLEM2	IB	Material property tabular function.
TABLEM3	IB	Material property tabular function.
TABLEM4	IB	Material property tabular function.
TABLES1	IB	Stress-dependent material tabular function for use in Piecewise Linear Analysis (D-6).
TABPCH	FMU	Punches selected tables on DTI bulk data cards.
TABPRT	FMU	Formats selected table data blocks for printing.
TABPT	FMU	Table printer.
TABRND1	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND2	IB	Tabular function for use in Random Analysis (D-8, D-11).

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TABRND3	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND4	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABS	P	Defines absolute reference temperature in heat transfer analysis.
TALL EDGE TICS	IC	Request for plotting all edge tic marks on upper half frame for X-Y plots.
TAPE	M	Write data block on physical tape (see FILE).
TCURVE	IC	Curve title for X-Y plot.
TEMP	IB	Grid temperature definition card.
TEMPAX	IB	Temperature definition for conical shell problem.
TEMPD	IB	Grid default temperature definition card.
TEMPERATURE	IC	Selects the temperature set to be used in both material property calculation and thermal loading.
TEMPLD\$	M	Indicates restart with change in thermal set for static loading.
TEMPMT\$	M	Indicates restart with change in thermal set for material properties.
TEMPMX\$	M	Indicates restart with change in thermal field with thermally dependent material properties.
TEMP(LØAD)	IC	Temperature set selection (applies to thermal load generation only).
TEMP(MAT)	IC	Temperature set selection (applies to material properties only).
TEMPP1	IB	Plate element temperature definition card.
TEMPP2	IB	Plate element temperature definition card.
TEMPP3	IB	Plate element temperature definition card.
TEMPRB	IB	One-dimensional element temperature definition.
TF	IB	Dynamic transfer function definition.
TF\$	M	Indicates restart with change in transfer function set selection.
TFL	IC	Transfer function set selection.
TFPØØL	DBT	Transfer function pool.
THERMAL	IC	Request for output of temperature vector in thermal analysis (UM-2.3).
THRU	IC	Forms strings of values within set declarations.
TIC	IB	Transient Initial Condition set definition card.

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TIME	IA	User time estimate for problem. This card is required in Executive Control Deck. Integer time value is in minutes.
TITLE	IC	Output labeling data for printer output.
TLEFT TICS	IC	Request for tic marks to be plotted on left hand edge of top half frame for X-Y plot.
TLØAD1	IB	Transient load set definition card.
TLØAD2	IB	Transient load set definition card.
Trailer	PH	A six word control block associated with a data block.
TRANRESP	P	Parameter used in SDR2 to indicate Transient Response Analysis (D-9, D-12).
TRANSIENT	IA	Selects rigid format for transient heat transfer analysis.
TRBSC	IC	Requests structure plot for all basic bending triangle elements.
TRD	FMS	Transient Response - Displacement.
TRHT	FMH	Integrates dynamic equation for heat transfer analysis.
TRIA1	IC	Requests structure plot for all TRIA1 elements.
TRIA2	IC	Requests structure plot for all TRIA2 elements.
TRIGHT TICS	IC	Request for tic marks to be plotted on right hand edge of top half frame for X-Y plots.
TRL	DBT	Transient Response List.
TRLG	FMH	Generates dynamic heat flux loads.
TRMEM	IC	Requests structure plot for all triangular membrane elements.
TRNSP	FMM	Transpose functional module.
TRPLT	IC	Request structure plot for all TRPLT elements.
TSTART	P	CPU time at start of flutter loop.
TSTEP	IB	Transient time steps for integration and output.
TSTEP	IC	Transient time step set selection.
TSTEP\$	M	Indicates restart with change in transient time step set selection.
TUBE	IC	Requests structure plot for all TUBE elements.
TWIST	IC	Requests structure plot for all TWIST elements.
TYPE	IC	Indicates paper type for structure plots.

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UBGV	DBM	Displacement vector for all grid points (D-4).
UBLL	DBM	$[U_{\ell\ell}^b]$ - Upper triangular factor of $[K_{\ell\ell}^b]$.
UBLV	DBM	Displacement solution vector (D-4).
UBØØV	DBM	Scalar multiple of UØØV in Differential Stiffness Rigid Format (D-4).
UDET	IB	Selects unsymmetric decomposition option for determinant method of real eigenvalue analysis.
UDV1T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT1. (D-9)
UDV2T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT2 (D-9).
UDVF	DBM	Displacement solution vector in a frequency response problem (D-8).
UDVT	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem (D-9).
UEVF	DBM	Displacement vector for extra points in a frequency response problem (D-11).
UEVT	DBM	Displacement vector for extra points in a transient response problem (D-12).
UGV	DBM	Displacement vector for all grid points (D-1, D-2, D-4, D-5).
UGV1	DBM	Successive sums of incremental displacement vectors. Piecewise Linear Analysis Rigid Format only (D-6).
UHVf	DBM	Modal frequency response solution vectors (D-11).
UHVT	DBM	Modal transient response solution vectors (D-12).
UINV	IB	Selects unsymmetric decomposition option for inverse power method of eigenvalue analysis.
ULL	DBM	$[U_{\ell\ell}]$ - Upper triangular factor of $[K_{\ell\ell}]$.
ULV	DBM	Displacement solution vector in static analyses (D-1, D-2, D-4, D-5).
UMERGE	FMM	Functional module to merge column matrices based on U-set.
UMF	IA	Requests User Master File as input source.
UMF	M	User Master File, a reserved NASTRAN physical unit (tape) which must be set up by the user when used.
UMFEDIT	IA	Requests User Master File operational mode of NASTRAN.
Unmodified Restart	PH	Restarting (see Restart) a problem without changing any data, other than output requests, of the previous run.
Unpool	PH	Remove data block from Pool Tape and place on a file for use by a functional module.
UNSØRT	IC	Requests unsorted echo of Bulk Data Deck (ECHØ=UNSØRT).

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U00	DBM	[U ₀₀] - Upper triangular factor of [K ₀₀].
U00V	DBM	Partition of displacement solution vector.
UPARTN	FMM	Functional module to partition matrices based on U-set.
UPPER TICS	IC	Request for tic marks to be plotted on upper edge of frame for X-Y plot.
UPV	DBM	Transient solution vectors for all physical points.
UPVC	DBM	Frequency response solution vectors for all physical points.
USET	DBT	Displacement set definitions. (PM-1.7.3)
USETA	DBT	Displacement set definitions table - Aerodynamics.
USETD	DBT	Displacement set definitions including extra scalar points introduced by dynamic analysis. (PM-1.7.3)
V	M	Used in parameter section of DMAP statement. Indicates that parameter is variable and may be changed by module. If changed value is to be used in subsequent DMAP instruction, it must be saved (see SAVE).
VANTAGE P0INT	IC	Location of observer for structure plot.
VDR	FMS	Vector Data Recovery.
VEC	FMU	Creates partitioning vector based on USET.
VECT0R	IC	Request for output of eigenvectors from real or complex eigenvalue analysis (D-3, D-5, D-7, D-10).
VECT0R	IC	Requests deformations on structure plot with vectors.
VEL0	IC	Abbreviated form of VEL0CITY.
VEL0CITY	IC	Output request statement for velocity vector. (UM-2.3, 4.2)
VFS	DBM	Partitioning vector for heat transfer analysis.
VIEW	IC	Rotation of object for structure plot.
VISC	IC	Request structure plot for all viscous damper element.
VPS	M	See XVPS.
VREF	PU	Velocity division factor.
W3	P	Pivotal frequency for uniform structure damping in the direct formulation of transient response problems (D-9).
W4	P	Pivotal frequency for element structural damping in the direct formulation of transient response problems (D-9).
WTMASS	P	Weight to mass conversion factor used in SMA2 and GPWG. Default value is 1.0.

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X	IC	Requests X vector for deformed structure plot.
XAXIS	IC	Request for drawing of X-axis for X-Y plot.
XBAXIS	IC	Request for drawing of X-axis on bottom half frame for X-Y plot.
XBGRID LINES	IC	Request for drawing grid lines for X-axis on bottom half frame for X-Y plot.
XCSA	EM	Executive Control Section Analysis. The preface module which processes the Executive Control Deck and prepares the control file on the New Problem Tape.
XDIVISIONS	IC	Request for division marking on X-axis.
XGPI	EM	Executive General Problem Initialization. The preface module whose principal function is to generate the ØSCAR. If the problem is a restart, XGPI initializes data blocks and named common blocks for proper restart.
XGRID LINES	IC	Request for grid lines to be drawn on X-axis for X-Y plots.
XINTERCEPT	IC	Specifies intercept of Y-axis on X-axis.
XLØG	IC	Request for logarithmic scales in X-direction.
XMAX	IC	Do not plot points whose X value lies above this value.
XMIN	IC	Do not plot points whose X value lies below this value.
XPAPER	IC	Specifies length of paper in X-direction for table plotter.
XQHHL	P	Appended QHHL data parameter.
XSFA	EM	Executive Segment File Allocator - the administrative manager of data blocks for NASTRAN.
XSØRT	EM	Executive sort routine - the preface module which reads and sorts the Bulk Data Deck and writes the sorted Bulk Data Deck on the New Problem Tape.
XTAXIS	IC	Request for drawing of X-axis on top half frame.
XTGRID LINES	IC	Request for drawing of grid lines on top half frame.
XTITLE	IC	X-axis title for X-Y plots.
XVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
XVPS	M	Variable Parameter Set Table. Executive table needed for restart. (PM-2.4)
XY	IC	Requests X and Y vectors for deformed structure plot.
XYCDB	DBT	SØRT3 type output requests (XYPLØTTER, XYPRINTER, Random Request).
XYØUT	IC	Request to generate X-Y plots.
XYØUT\$	M	Indicates restart with an X-Y plot request.
XYPEAK	IC	Request to print the maximum and minimum values of the specified response.

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XYPLØT	FMS	X-Y plot generator.
XYPLØT	IC	Request to generate X-Y plots.
XYPLTF	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTFA	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTR	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTT	DBT	XYPLØT input data block. (D-9, D-12)
XYPLTTA	DBT	XYPLØT input data block. (D-9, D-12)
XYPRINT	IC	Request to tabulate XY pairs on the printer.
XYPRNPLT	FMU	Dummy output module.
XYPUNCH	IC	Request to punch XY pairs.
XYTRAN	FMS	XY output translator.
XYZ	IC	Requests X, Y and Z vectors for deformed structure plot.
XZ	IC	Requests X and Z vectors for deformed structure plot.

NASTRAN DICTIONARY

Y	IC	Requests Y vector for deformed structure plot.
Y	M	Used in parameter section of DMAP statement. Indicates that parameter may be given an initial value with a PARAM bulk data card.
YAXIS	IC	Request for drawing of Y-axis.
YBDIVISIØNS	IC	Request for division marking on Y-axis of lower half frame.
YBGRID LINES	IC	Request for grid lines to be drawn on Y-axis of lower half frame.
YBINTERCEPT	IC	Specifies intercept of X-axis on Y-axis on lower half frame.
YBLØG	IC	Request for logarithmic scales in Y-direction on lower half frame.
YBMAX	IC	Do not plot points whose Y value lies above this value for lower half frame.
YBMIN	IC	Do not plot points whose Y value lies below this value for lower half frame.
YBS	DBM	Scalar multiple of YS matrix. Used in Differential Stiffness Rigid Format only. (D-4).
YBTITLE	IC	Y-axis title on lower half frame.
YBVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YDIVISIØNS	IC	Request for division marking on Y-axis.
YES	IA	Option used on CHKPNT card, indicates that checkpoint is desired.
YGRID LINES	IC	Request for grid lines to be drawn on Y-axis.
YINTERCEPT	IC	Specifies intercept of X-axis on Y-axis.
YLØG	IC	Request for logarithmic scales in Y-direction.
YMAX	IC	Do not plot points whose Y value lies above this value.
YMIN	IC	Do not plot points whose Y value lies below this value.
YPAPER	IC	Specifies length of paper in Y-direction for table plotter.
YS	DBM	{Y _S } - Constrained displacement vector.
YTDIVISIØNS	IC	Request for division marking on Y-axis for upper half frame.
YTGRID LINES	IC	Request for grid lines to be drawn on Y-axis for upper half frame.
YTINTERCEPT	IC	Specifies intercept of X-axis on Y-axis for upper half frame.
YTITLE	IC	Y-axis title.
YTLØG	IC	Request for logarithmic scales in Y-direction for upper half frame.

NASTRAN DICTIONARY

YTMAX	IC	Do not plot points whose Y value lies above this value for upper half frame.
YTMIN	IC	Do not plot points whose Y value lies below this value for upper half frame.
YTITLE	IC	Y-axis title for upper half frame.
YVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval for upper half frame.
YVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YZ	IC	Requests Y and Z vectors for deformed structure plot.

IC Requests Z vector for deformed structure plot.

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AUTOMATED MUTLI-STAGE SUBSTRUCTURING

A new SØF composed of five physical files would be declared as follows:

```
SØF(1)=SØF1,200,NEW  
SØF(2)=SØF2,200  
SØF(3)=SØF3,400  
SØF(4)=SØF4,600  
SØF(5)=SØF5,700
```

All data stored on the SØF is accessed via the substructure name. For each substructure, various types of SØF data may be stored. These types of data are called items and are accessed via their item names. Thus, the substructure name and item name are all that is required to access any block of data on the SØF. The items which can be stored for any substructure are described in Table 2. The program automatically keeps track of the data, stores the data as it is created, and retrieves these data when required. The user's only responsibility is to maintain the file. It must be accessible by the system when needed. The user must remove items already created in the event input errors were detected during processing or if that data is no longer needed for subsequent analyses.

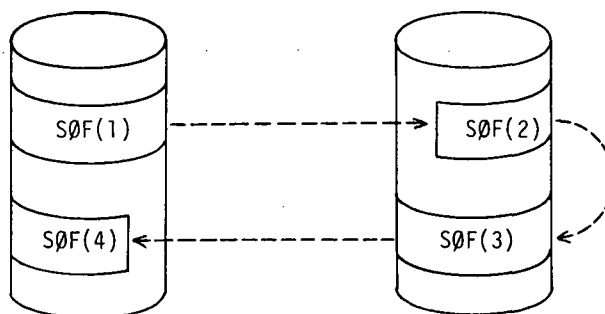


Figure 4. Substructure Operating File (SØF).

1.14.3 The Case Control Deck for Substructuring Analyses

The Case Control Deck controls loading conditions, constraint set selection, output requests, and so forth in a substructuring analysis just as in a non-substructuring analysis. However, in a substructuring analysis, there are very important relationships among the Case Control Decks to be input for the three Phases of a substructuring analysis. Compatibility among the substructuring Phases must be maintained for load sets, constraint sets, and subcase definitions. This section will describe how the Case Control Deck should be used for each of the three Phases.

STRUCTURAL MODELING

1.14.3.1 Phase 1

The following requirements must be satisfied by the Case Control Deck in Phase 1:

1. Constraint set selections (MPC, SPC) must be above the subcase level. That is, only one set of constraints is allowed in Phase 1 for all loading conditions.
2. One subcase must be defined for each loading condition which is to be saved on the SØF. The loading condition may consist of any combination of external static loads, thermal loads, element deformation loads, or enforced displacements. Loading conditions which are not saved on the SØF in Phase 1 cannot be used in any solution in Phase 2.

1.14.3.2 Phase 2

The Phase 2 Case Control Deck is exactly like the Case Control used in a non-substructuring analysis. It is only needed, however, if plots are requested or when there is a SØLVE command in the Substructure Control Deck. In this latter case, the subcase definitions, load and constraint set selections, etc. are used in the usual fashion to control the solution process.

Case Control output requests are honored only if there is a PRINT subcommand under the RECØVER command in the Substructure Control Deck. If a RECØVER command with a PRINT or SAVE subcommand is used for a solution obtained in a previous execution, the Case Control should be identical (except for output requests) to that used to obtain that solution.

1.14.3.3 Phase 3

The following requirements must be satisfied by the Case Control Deck in Phase 3:

1. Constraint sets (MPC, SPC) must be identical to those used in Phase 1 for this substructure.
2. The subcase definition for load set IDs must be identical to those used in Phase 1 for this substructure including those for appended loads, if any. All load definitions must appear in the order generated.
3. The subcase definition for the Phase 3 output requests for solution vectors generated in Phase 2 must be merged with the above subcase definition for load set IDs. Note, the ØLOAD output requested in Phase 3 will correspond to the load factors defined during Phase 2 solution, not those defined by Phase 3 Case Control.

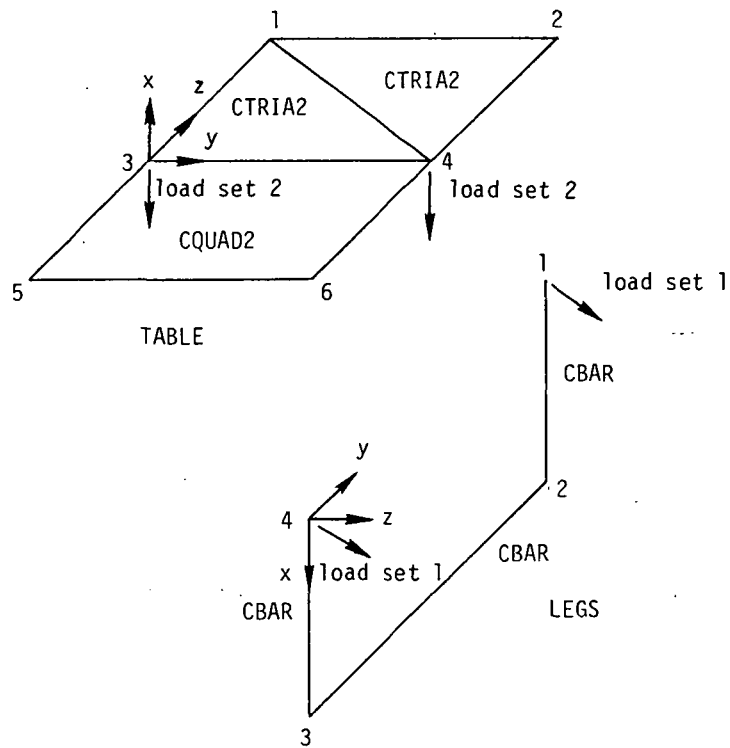
AUTOMATED MULTI-STAGE SUBSTRUCTURING

The number of Phase 3 subcases required is the maximum of those defined in Phase 1 and Phase 2. All output requests will correspond to the Phase 2 subcase sequence, starting with the first subcase defined in Phase 3. It is essential to assign the same thermal and element deformation loadings to the same subcase in both Phase 1 and Phase 2 in order to provide the correct Phase 1 load data to the Phase 3 output processing of element stresses.

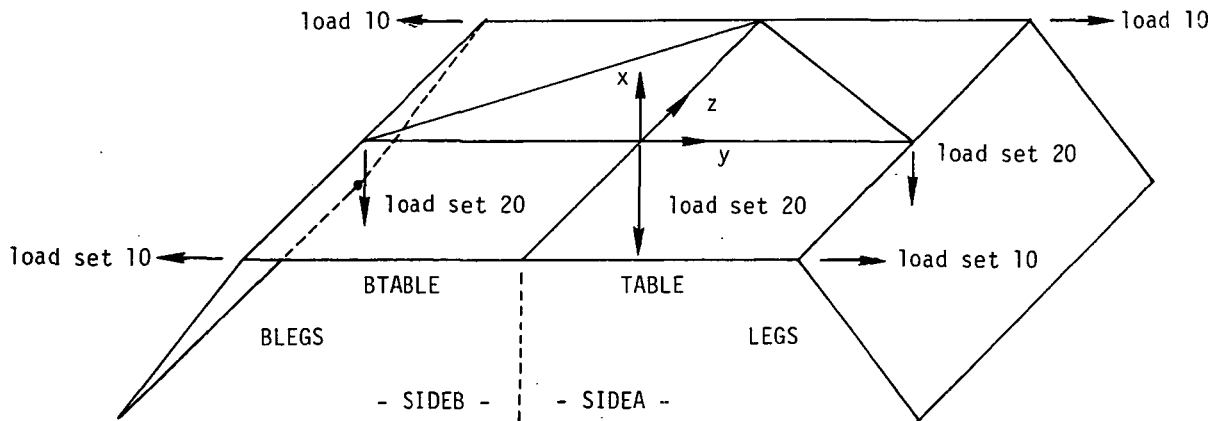
1.14.4 Example of Substructure Analysis

This example illustrates a simple substructuring analysis. Figure 5a shows two basic substructures, TABLE and LEGS. Note that these structures have different basic coordinate systems as shown in the figure. Figure 5b shows a combined structure which is assembled from the basic substructures. The entire data decks to generate and analyze this structure are listed in Tables 3 - 6. These include the data for the generation of the basic substructures in Phase 1, the assembly of the complete structure, solution, and data recovery in Phase 2, and the data recovery in Phase 3. The remainder of this section is devoted to a detailed description of each of the data decks used in this analysis.

STRUCTURAL MODELING



a. Phase 1 basic substructures.



b. Phase 2 combined substructure.

Figure 5. Substructure example problem.

NASTRAN DATA DECK

2.1 GENERAL DESCRIPTION OF DATA DECK

The input deck begins with the required resident operating system control cards. The type and number of these cards will vary with the installation. Instructions for the preparation of these control cards should be obtained from the programming staff at each installation.

The operating system control cards are followed by the NASTRAN Data Deck (see Figure 1), which is constructed in the following order (depending on the particular job requirements):

1. The NASTRAN Card
2. The Executive Control Deck
3. The Substructure Control Deck
4. The Case Control Deck
5. The Bulk Data Deck
6. The INPUT Module Data Card(s)

The NASTRAN card is used to change the default values for certain operational parameters, such as buffer size and machine model number. The NASTRAN card is optional, but, if present, it must be the first card of the NASTRAN Data Deck. The NASTRAN card is a free-field card (similar to cards in the Executive Control Deck). Its format is as follows:

NASTRAN keyword₁ = value, keyword₂ = value, . . .

The most frequently used keywords are as follows:

1. BUFFSIZE - Defines the number of words in a GINØ buffer. Usually this value is standardized at any particular installation. However, the desired value may be different from the default value of 1803 (IBM), 1183 (CDC) and 871 (UNIVAC). In any event, related runs, such as restarts and User Master File runs, must use the same BUFFSIZE for all parts of the runs.
2. CØNFIG - Defines the model number of the configuration for use in timing equations for matrix operations. Entries exist for the following configurations:

<u>MACHINE</u>	<u>CØNFIG</u>	<u>MØDEL NØ.</u>
IBM 360/370	0 (default)	91, 95
	3	50
	4	65
	5	75
	6	85
	7	195
	9	155
	10	165

NASTRAN DATA DECK

<u>MACHINE</u>	<u>CØNFIG</u>	<u>MØDEL NØ.</u>
CDC 6000	0 (default)	6600
	6	6400
UNIVAC 1100	0 (default)	1108/1110

The machine type is automatically determined by NASTRAN. If the model number is the default, the CØNFIG keyword is not needed on the NASTRAN card. It is important to indicate the proper configuration; otherwise, all time-dependent matrix decisions will be incorrect.

3. MØDCØM(i) - Defines a nine-word array for module communications. Currently, only MØDCØM(1) is supported. If MØDCØM(1) = 1, diagnostic statistics from subroutine SDCØMP are printed.
4. HICØRE - Defines the amount of open core available to the user on the UNIVAC 1100 series machines. The user area default is nominally 65K decimal words. The ability to increase this value may be installation limited.
5. FILES - Establishes NASTRAN permanent files as being disk files rather than tape files. The FILES are PØØL, ØPTP, NPTP, UMF, NUMF, PLT1, PLT2, INPT, INP1, INP9. Multiple file names must be enclosed with parentheses such as FILES = (UMF,NPTP). The FILES parameter(s) must be last on the NASTRAN card. Note the plot files, PLT1 and PLT2, are not supported on the UNIVAC, therefore a physical tape must be assigned prior to job execution.

Additional information for all NASTRAN card options is given in Section 6.3.1 of the Programmer's Manual.

The Executive Control Deck begins with the NASTRAN ID card and ends with the CEND card. It identifies the job and the type of solution to be performed. It also declares the general conditions under which the job is to be executed, such as, maximum time allowed, type of system diagnostics desired, restart conditions, and whether or not the job is to be checkpointed. If the job is to be executed with a rigid format, the number of the rigid format is declared along with any alterations to the rigid format that may be desired. If Direct Matrix Abstraction is used, the complete DMAP sequence must appear in the Executive Control Deck. The executive control cards and examples of their use are described in Section 2.2.

NASTRAN DATA DECK

2.7 SUBSTRUCTURE CONTROL DECK

The Substructure Control Deck options provide the user commands needed to control the execution of NASTRAN for automated multi-stage substructure analyses. These commands are input on cards with the same format conventions as are used for the normal NASTRAN Case Control Deck.

Initiation of a substructure analysis is achieved via the Executive Control Deck command (see Section 2.1):

APP DISPLACEMENT,SUBS

This command directs NASTRAN to automatically generate the required DMAP sequence of alters to the specified Rigid Format necessary to perform the operations requested in the Substructure Control Deck. Following the Substructure Control Deck in the NASTRAN input data stream comes the standard Case Control Deck which specifies the loading conditions, omit sets, method of eigenvalue extraction, element sets for plotting, plot control, and output requests, etc.

The Substructure Control Deck commands are summarized in Table 1 where they are listed under one of three categories according to whether they:

1. Specify the phase and mode of execution
2. Specify the substructuring matrix operations
3. Define and control the substructure operating file (SØF)

Several commands have associated with them a set of subcommands used to specify additional control information appropriate to the processing requested by the primary command. These subcommands are defined together with the alphabetically sorted descriptions of their primary commands in Section 2.7.3. Examples utilizing these commands are presented in Section 1.

The sections that follow discuss the interaction between the substructure commands and the standard case control commands, the translation of substructure commands into DMAP ALTER sequences, and the format conventions to be used. The bulk data cards provided for substructure analyses are included with the standard bulk data descriptions in Section 2.3 and they are summarized for convenient reference in Table 2.

Table 1. Summary of substructure commands.

A. Phase and Mode Control	
SUBSTRUCTURE #	- Defines execution phase (1, 2, or 3) (Required)
OPTIONS	- Defines matrix options (K, M, P, or PA)
RUN	- Limits mode of execution (DRY, G0, DRYG0, STEP)
ENDSUBS #	- Terminates Substructure Control Deck (Required)
B. Substructure Operations	
COMBINE	- Combines sets of substructures
NAME*	- Names the resulting substructure
TOLERANCE*	- Limits distance between automatically connected grids
CONNECT	- Defines sets for manually connected grids and releases
OUTPUT	- Specified optional output results
COMPONENT	- Identifies component substructure for special processing
TRANSFORM	- Defines transformations for named component substructures
SYMMTRANSFORM	- Specifies symmetry transformation
SEARCH	- Limits search for automatic connects
EQUIV	- Creates a new equivalent substructure
PREFIX*	- Prefix to rename equivalenced lower level substructures
REDUCE	- Reduces substructure matrices
NAME*	- Names the resulting substructure
BOUNDARY*	- Defines set of retained degrees of freedom
OUTPUT	- Specifies optional output requests
SAVE	- Save REDUCE decomposition product
SOLVE	- Initiates substructure solution (statics or normal modes)
RECOVER	- Recovers Phase 2 solution data
SAVE	- Stores solution data on S0F
PRINT	- Stores solution and prints data requested
DISP	- Displacement output request
SPCF	- Reaction force output request
LOAD	- Applied load output request
BASIC	- Basic substructure for output requests
SORT	- Output sort order
SUBCASES	- Subcase output request
MODES	- Modes output request
RANGE	- Mode range output request
BRECOVER	- Basic substructure data recovery, Phase 3
PL0T	- Initiates substructure undeformed plots

Mandatory Control Cards

* Required Subcommand

SUBSTRUCTURE CONTROL DECK

Table 1. Summary of substructure commands (continued).

C. SØF Controls	
SØF #	- Assigns physical files for storage of the SØF (Required)
PASSWØRD*	- Protects and ensures access to correct file
SØFØUT or SØFIN	- Copies SØF data to or from an external file
PØSITION	- Specifies initial position of input file
NAMES	- Specifies substructure name used for input
ITEMS	- Specifies data items to be copies in
SØFPRINT	- Prints selected items from the SØF
DUMP	- Dumps entire SØF to a backup file
RESTØRE	- Restores entire SØF from a previous DUMP operation
CHECK	- Checks contents of external file created by SØFØUT
DELETE	- Edits out selected groups of items from the SØF
EDIT	- Edits out selected groups of items from the SØF
DESTRØY	- Destroys <u>all</u> data for a named substructure and all the substructures of which it is a component

Mandatory Control Cards

* Required Subcommand

SUBSTRUCTURE CONTROL DECK

Substructure Command COMBINE - Combine Sets of Substructures

Purpose: This operation will perform the operations to combine the matrices and loads up to seven substructures into matrices and loads representing a new pseudostructure. Each component structure may be translated, rotated, and reflected before it is connected. The user may manually select the points to be connected or direct the program to connect them automatically.

Request Format:

COMBINE ({ $\frac{AUT\emptyset}{MAN}$ }, { $\frac{X}{Y}{Z}$ }) name1, name2, etc.

Subcommands:

NAME = new name (required)
 TOLERANCE = ϵ (required)
 CONNECT = n
 OUTPUT = m_1, m_2, \dots

Each individual component substructure may have the following added commands:

COMPONENT	= name	} repeat for each component
TRANSFORM	= m	
SymTRANSFORM	= { $\frac{X}{Y}{Z}{XY}{XZ}{YZ}{XYZ}$ }	
SEARCH	= namej, namek, etc.	

Definitions:

- AUT \emptyset /MAN - Defines method of connecting points. If AUT \emptyset is chosen, the physical location of grid points is used to determine connections. If MAN, all connections are defined on CONCT or CONCT1 bulk data.
- X, Y, Z - Are used on COMBINE card for searching geometry data for AUT \emptyset connections. Denotes preferred search direction for processing efficiency.
- name1, name2, etc. - Unique names of substructures to be combined. Limits are from one to seven component structures.
- new name - Defines name of combination structure (required).
- ϵ - Defines limit of distance between points which will be automatically connected (real > 0).
- n - Defines set number of manual connections and releases specified on bulk data cards, CONCT, CONCT1, and RELES.
- name - On COMPONENT card defines which substructure (name1, etc.) to which the following data is applied.

NASTRAN DATA DECK

- m - Set identification number of TRANS and GTRAN bulk data cards which define the orientation of the substructure and/or selected grid points relative to new basic coordinates.
- X,Y,...XY,...XYZ - Defines axis (or set of axes) normal to the plane(s) of symmetry in the new basic coordinate system. The displacement and location coordinates in these directions will be reversed in sign.
- namej - Limits the automatic connection process such that only connections between component "name" and these structures are produced. Multiple search commands may appear for any one component (see Note 4).
- m₁, m₂, etc. - Optional output requests (see Note 5).

- Notes:
1. The automatic connections are produced by first sorting the grid point coordinates in the specified coordinate direction and then searching within limited groups of coordinates. If the boundary of a substructure to be connected is aligned primarily along one of the coordinate axes, this axis should be used as the preferred search direction. If the boundary is parallel with, say, the yz plane and all boundary coordinates have a constant x value, then the search should be specified along either the y or the z axis.
 2. The transformation (TRANS) data defines the orientation of the component substructure (old basic) in terms of the new basic coordinate system. All grid points originally defined in the old basic system will be transformed to the new basic system. Points defined in local coordinate systems will not be transformed unless otherwise specified on a GTRAN card, and their directions will rotate with the substructure.
 3. The SYMTRANSFORM (or SYMT) request is primarily used to produce symmetric reflections of a structure. This is usually preceded by an EQUIV command to produce a new, unique substructure name. Note that the results for the new reflected substructure may reference a left-handed coordinate system wherever local coordinate systems are retained during the transformation. However, those coordinates which are originally in the old basic or are newly specified via a GTRAN card are automatically transformed to a right-handed coordinate system of the combined structure during the combination process.
 4. If any search option is present then all connections between substructures must be specified explicitly with SEARCH commands. Only those combinations specified will be searched for possible connects. Symmetric connects need not be declared (i.e., COMPONENT A SEARCH B implies COMPONENT B SEARCH A). The user is warned that care must be taken to assure all proper connections of substructures should any SEARCH commands be utilized.
 5. The following output requests are available for the COMBINE operation (* marks recommended output options):

<u>CODE</u>	<u>OUTPUT</u>
2*	SOF table of contents
3	CONNECT1 bulk data summary
4	CONNECT bulk data summary
6	GTRAN bulk data summary
7*	TRANS bulk data summary
9	RELES bulk data summary
11	Summary of automatically-generated connections (in terms of internal point numbers)
12*	Complete connectivity map of final combined pseudostructure defining each internal point in terms of the grid point ID and component substructure it represents

SUBSTRUCTURE CONTROL DECK

13	The EQSS item	}	Output printed is formatted SØF data for the newly created pseudostructure (See Section 1.14 for definitions)
14	The BGSS item		
15	The CSTM item		
16	The PLTS item		
17	The LØDS item		

Examples:

1. COMBINE PANEL SPAR
TØLE = .0001
NAME = SECTA
2. COMBINE (AUTØ,Z) TANK1, TANK2, BULKHD
NAME = TANKS
TØLE = .01
COMPØNENT TANK1
TRAN = 4
SEARCH = BULKHD
COMPØNENT TANK2
SEARCH = BULKHD
3. COMBINE (MAN) LWING, RWING
TØLE = 1.0
NAME = WING
COMPØNENT LWING
SYMØ = Y

NASTRAN DATA DECK

Substructure Command DELETE

Purpose: To delete individual substructure items from the SØF.

Request Format:

DELETE name, item1, item2, item3, item4, item5

Subcommands: None

Definitions:

name - Substructure name

item1, item2,... - Item names (HØRG, KMTR, LØDS, SØLN, etc.)

- Notes:
1. DELETE may be used to remove from one to five items of any single substructure.
 2. For primary substructures, items of related secondary substructures are removed only if the later point to the same data (KMTX, MMTX, etc.).
 3. For secondary and image substructures, no action is taken on items of related substructures, i.e., items of equivalenced substructures or higher or lower level substructures.
 4. See the EDIT and DESTROY commands for other means of removing substructure data.

SUBSTRUCTURE CONTROL DECK

Substructure Command EDIT - Selectively Removes Data from SØF File

Purpose: To permanently remove selected substructure data from the SØF.

Request Format:

EDIT (opt) name

Subcommands: None

Definitions:

name - Name of substructure.

opt - Integer value reflecting combinations of requests. The sum of the following integers defines the combination of data items to be removed from the SØF.

<u>ØPT</u>	<u>Items Removed</u>
1	Stiffness Matrix (KMTX)
2	Mass Matrix (MMTX)
4	Load Data (LØDS, LØAP, PVEC, PAPP)
8	Solution Data (UVEC, QVEC, SØLN)
16	Transformation Matrices defining next level (HØRG, UPRT, PØVE, PØAP, LMTX)
32	All items for the substructure
64	Appended loads data (LØAP, PAPP, PØAP)

- Notes:
1. The user is cautioned on the removal of the HØRG matrix data. These matrices are required for the recovery of the solution results.
 2. For primary substructures, items of related secondary substructures are removed only if they point to the same data (KMTX, MMTX, etc.).
 3. For secondary and image substructures, no action is taken on items of related substructures, i.e., items of equivalenced or higher or lower level substructures.
 4. If the EDIT feature is to be employed, the user should consider also using SØFØUT to ensure the existence of backup data in the event of an error.
 5. See DELETE and DESTROY for other means of removing substructure data.

NASTRAN DATA DECK

Substructure Command EQUIV - Create a New Equivalent Substructure

Purpose: To assign an alias to an existing substructure and thereby create a new equivalent substructure. The new secondary substructure may be referenced independently of the original primary substructure in subsequent substructure commands. However, the data actually used in substructuring operations is that of the primary substructure.

Request Format:

EQUIV name1, name2

Subcommands:

PREFIX = p

Definitions:

- p - Single BCD character.
- name1 - Existing primary substructure name.
- name2 - New equivalent substructure name.

- Notes:
1. A substructure created by this command is referred to as a secondary substructure.
 2. All substructures which were used to produce the primary substructure will produce equivalent image substructures. The new image substructure names will have the prefix p.
 3. A DESTROY operation on the primary substructure data will also destroy the secondary substructure data and all image substructures.
 4. An EDIT or DELETE operation on the primary substructure will not remove data of the secondary substructure and vice versa.

SUBSTRUCTURE CONTROL DECK

Substructure Mode Control ØPTIØNS - Defines Matrix Types

Purpose: This allows the user to selectively control the type of matrices being processed.

Request Format:

ØPTIØNS m1,m2,m3

Subcommands: None

Definition:

m1,m2,m3 - Any combination of the characters K, M, and either P or PA, where:

K = Stiffness Matrices
M = Mass Matrices
P = Load Matrices
PA = Appended Load Vectors

Notes: 1. The default depends on the NASTRAN rigid format:

<u>Rigid Format</u>	<u>Default</u>
1 - Statics	K,P
2 - Inertia Relief	K,M,P
3 - Normal Modes	K,M

- In a Phase 1 execution, Rigid Formats 1 and 3 will provide only two of the matrices, as shown above. In Rigid Format 1, the mass matrix is not generated. In Rigid Format 3, the loads matrix is not generated. An error condition will result unless the user adds the required DMAP alters to provide the requested data.
- Stiffness, mass, or load matrices must exist if the corresponding K, M, P, or PA option is requested in the subsequent Phase 2 run.
- Matrices or loads may be modified by rerunning the substructure sequence for only the desired type. However, the old data must be deleted first with the EDIT or DELETE command. See Section 1.14 for the actual item names.
- The append load option, PA, is used when additional load sets are required for solution, and it is not desired to regenerate existing loads. To generate these new load vectors, re-execute all required Phase 1 runs with the new load sets and ØPTIØN = PA. Then, repeat the Phase 2 operations with ØPTIØN = PA. At each step, the new vectors are appended to the existing loads so that all load vectors will be available in the SØLVE stage.
- Each ØPTIØN command overrides the preceding command to control subsequent steps of the substructure process.
- When executing the SØLVE command, the option selected must provide the matrices required for the rigid format being executed.

NASTRAN DATA DECK

Substructure Operating File Declaration PASSWØRD

Purpose: This declaration is required in the substructure command deck. The password is written on the SØF file and is used to protect the file and insure that the correct file is assigned for the current run.

Request Format:

PASSWØRD password

Subcommands: None

Definition:

password - BCD password for the SØF (8 characters maximum). See the SØF file declaration card description.

SUBSTRUCTURE CONTROL DECK

Substructure Command PLØT - Substructure Plot Command

Purpose: This operation is used to plot the undeformed shape of a substructure which may be composed of several component substructures. This command initiates the execution of a plot at any stage of the substructure process. The actual plot commands; origin data, etc., must be included in the normal case control data.

Request Format:

PLØT name

Subcommands: None

Definitions:

name - Name of component substructure to be plotted.

- Notes:
1. The set of elements to be plotted will consist of all the elements and grid points saved in Phase 1 for each basic substructure comprising the substructures named in the PLØT command. (Only one plot set from each basic substructure is saved in Phase 1.)
 2. The structure plotter output request packet, while part of the standard Case Control Deck, are treated separately in Sections 4.2 and 4.3, respectively.

MASTRAN DATA DECK

Substructure Command RECOVER - Phase 2 Solution Data Recovery

Purpose: This operation recovers displacements and boundary forces on specified substructures in the Phase 2 execution. The results are saved on the SØF file and they may be printed upon user request. This command should be input after the SØLVE command to store the solution results on the SØF file.

Request Format:

RECOVER s-name

Subcommands:

SAVE = name

PRINT = name

DISP = $\begin{Bmatrix} \text{ALL} \\ n \\ \text{NONE} \end{Bmatrix}$

SPCF = $\begin{Bmatrix} \text{ALL} \\ n \\ \text{NONE} \end{Bmatrix}$

ØLOAD = $\begin{Bmatrix} \text{ALL} \\ n \\ \text{NONE} \end{Bmatrix}$

BASIC = b-name

for static analysis only:

SØRT = $\begin{Bmatrix} \text{SUPCASE} \\ \text{SUBSTRUCTURE} \end{Bmatrix}$

SUBCASES = $\begin{Bmatrix} \text{ALL} \\ n \\ \text{NONE} \end{Bmatrix}$

for dynamic analysis only:

SØRT = $\begin{Bmatrix} \text{MØDES} \\ \text{SUBSTRUCTURE} \end{Bmatrix}$

MØDES = $\begin{Bmatrix} \text{ALL} \\ n \\ \text{NONE} \end{Bmatrix}$

RANGE = λ_1, λ_2

Definitions:

s-name - Name of the substructure named in a prior SØLVE command from which the solution results are to be recovered.

name - Name of the component structure for which results are to be recovered. May be the same as "s-name".

SUBSTRUCTURE CONTROL DECK

- b-name - Name of component basic substructure that following output requests are to apply to.
- ALL - Output for all points will be produced.
- NONE - No output is to be produced.
- n - Set identification number of a SET card appearing in Case Control. Only output for those points, subcases, or modes whose identification number appears on this SET card will be produced.
- λ_1, λ_2 - Range of eigenvalues for which output will be produced. If only λ_1 is present the range is assumed to be $0 - \lambda_1$.
- SUBCASE - All output requests for each subcase will appear together.
- MODES - All output requests for each mode will appear together.
- SUBSTRUCTURE - All output requests for each basic substructure will appear together.

Output Requests: Printed output produced by the RECOVER PRINT command can be controlled by requests present in either Case Control or the RECOVER command in the Substructure Control Deck. If no output requests are present, the PRINT command is equivalent to SAVE and no output will be printed.

The RECOVER output options described above may appear after any PRINT command. These output requests will then override any Case Control requests. The output requests for any PRINT command can also be specified for any or all basic component substructures of the results being recovered. These requests will then override any requests in Case Control or after the PRINT command.

Example of output control:

```

RECOVER SØLSTRCT
PRINT  ABSC
    SØRT = SUBSTRUCTURE } basic defaults for ABDC output
    DISP = ALL
    ØLOAD = 10
    BASIC  A              } override requests for BASIC  A
        DISP = 5
    BASIC  C              } override requests for BASIC  C
        ØLOAD = NONE
        SURCASES = 20
SAVE   ABC

```

- Notes:
1. SAVE will save the solution for substructure "name" on the SØF. PRINT will save and print the solution.
 2. If the solution data already exists on the SØF, the existing data can be printed without costs of regeneration with the PRINT command.
 3. For efficiency, the user should order multiple SAVE and/or PRINT commands so as to trace one branch at a time starting from his solution structure.
 4. Reaction forces are computed for a substructure only if (1) the substructure is named on a PRINT subcommand and, (2) an output request for SPCFØRCE exists in the Case Control or the RECOVER command.
 5. All set definitions should appear in Case Control to ensure their availability to the RECOVER module.
 6. The SØRT output option should only appear after a PRINT command. Any SØRT commands appearing after a BASIC command will be ignored.

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7. If both a `MODES` request and a `RANGE` request appear for dynamic analysis, both requests must be satisfied for any output to be produced.
8. The media, print or punch, where output is produced is controlled through Case Control requests. If no Case Control requests are present, the default of print is used.

SUBSTRUCTURE CONTROL DECK

Examples:

1. Create a new SØF file with a filename of SØF1 and catalogue it.

```
REQUEST(SØF1,*PF)
NASTRAN.
CATALØG(SØF1,username)
789
.
.
.
NASTRAN data cards including the SØF declaration --
SØF(1)=SØF1,1000,NEW
.
.
.
6789
```

2. Use of an existing SØF file with a filename of ABCD.

```
ATTACH(ABCD,username)
NASTRAN.
EXTEND(ABCD)
789
.
.
.
NASTRAN data cards including the SØF declaration --
SØF(1)=ABCD,1000
.
.
.
6789
```

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The filename used on the SØF declaration must specify one of the NASTRAN user files INPT, INP1,..., INP9.

Examples:

1. Create a new SØF file named INPT.

```
@ASG,U INPT.,F///1000
@HDG,N
@XQT *NASTRAN.LINK1
NASTRAN FILES=INPT
NASTRAN data cards including the SØF declaration --
SØF(1)=INPT,400,NEW
.
.
.
@ADD,P *NASTRAN.CØNTRL
@FIN
```

2. Use of an existing SØF file with a filename of INP7.

```
@ASG,AX INP7.
@HDG,N
@XQT *NASTRAN.LINK1
NASTRAN FILES=INP7
NASTRAN data cards including the SØF declaration --
SØF(1)=INP7,250
.
.
.
@ADD,P *NASTRAN.CØNTRL
@FIN
```


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IBM 360/370

The file name used on the SØF declaration must specify a FØRTRAN unit by using the form FTxx from the table of allowable file names shown below which correspond to the direct access devices that are supported under the SØF implementation. The allocation of space for the direct access FØRTRAN data sets can be made in terms of blocks, tracks or cylinder. If the allocation is in blocks, the block size in the space allocation corresponds to (BUFFSIZE-4)*4 bytes where BUFFSIZE is the GINØ buffer size found in SYSTEM(1).

In order to use the SØF on IBM computers, it is necessary to specify the PARM on the EXEC PGM=NASTRAN card. This PARM sets the amount of core (in bytes) NASTRAN releases to the operating system for system use and FØRTRAN buffers. The following formula should be used to determine the value for the PARM:

$$\text{PARM} = \begin{cases} (4096 + m*((\text{BUFFSIZE}-4) + 64))*4 & \text{single buffering, BUFNO=1} \\ (4096 + m*(2*(\text{BUFFSIZE}-4) + 96))*4 & \text{double buffering, BUFNO=2} \end{cases}$$

where m = number of physical datasets comprising the SØF.

Examples:

1. Create a new SØF data set with a filename of FT11.

```
//NSGØ EXEC NASTRAN,PARM.NS='CØRE=(,24K)'
//NS.FT11F001 DD DSN = User Name, UNIT=2314, VØL=SER=User No.,
// DISP=(NEW,KEEP), SPACE=(TRK,(1000)), DCB=BUFNO=1
//NS.SYSIN DD *
NASTRAN BUFFSIZE=1826
:
:
NASTRAN data cards including the SØF declaration --
SØF(1)=FT11,,NEW
:
:
/*
```

Notes:

1. The SØF parameters - filename, filesize, and (ØLD/NEW) are positional parameters. The filesize parameter is not required for IBM 360/370 computers, but its position must be noted if NEW is coded for the SØF file.
 2. The dataset disposition must be DISP=(NEW,KEEP) when the SØF dataset is created. However, an existing SØF dataset may be re-initialized by coding NEW on the SØF declaration in the NASTRAN data deck. In this case, the disposition on the DD card must be coded DISP=ØLD.
2. Use of an existing SØF dataset with a filename of FT23.

```
//NS EXEC NASTRAN,PARM.NS='CØRE=(,72K)'
//NS.FT23F001 DD DSN = User Name, UNIT=3330, VØL=SER=User No.,
// DCB=BUFNO=1, DISP=ØLD
//NS.SYSIN DD *
NASTRAN BUFFSIZE=3260
SØF(1)=FT23
:
:
/*
```

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SØF File Name	FØRTRAN Unit DDName	SØF File Name	FØRTRAN Unit DDName
FT02	FT02F001	FT16	FT16F001
FT03	FT03F001	FT17	FT17F001
FT08	FT08F001	FT18	FT18F001
FT09	FT09F001	FT19	FT19F001
FT10	FT10F001	FT20	FT20F001
FT11	FT11F001	FT21	FT21F001
FT12	FT12F001	FT22	FT22F001
FT15	FT15F001	FT23	FT23F001
Note: A maximum of 10 SØF file names is allowed in any NASTRAN substructuring run.			

SUBSTRUCTURE CONTROL DECK

Substructure Command SØFPRINT

Purpose: To print selected contents of the SØF file for data checking purposes.

Request Format:

SØFPRINT(opt) name, item1, item2, etc.

Subcommands: None

Definitions:

opt - integer, control option, default = 0.
opt = 1: prints data items only
opt = 0: prints table of contents
opt = -1: prints both

name - Name of substructure for which data is to be printed.

item1, item2 - SØF item name, used only when opt ≠ 0, limit = 5 (See Table 2, Section 1.14).

Notes: 1. If only the table of contents is desired (opt = 0), this command may be coded:

SØFPRINT TØC

On the page heading for the table of contents, the labels are defined as follows:

IS - Image substructure flag. 0 - not an image substructure
1 - image substructure

SS - Secondary substructure number (successor)

PS - Primary substructure number (predecessor)

LL - Lower level substructure number

CS - Combined substructure number

HL - Higher level substructure number

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Substructure Command SØLVE - Substructure Solution

Purpose: This command initiates the substructure solution phase. The tables and matrices for the pseudostructure are converted to their equivalent NASTRAN data blocks. The substructure grid points referenced on bulk data cards SPCS, MPC, etc., are converted to pseudostructure scalar point identification numbers. The NASTRAN execution then proceeds as though a normal structure were being processed.

Request Format:

SØLVE name

Subcommands: None (Case Control and Bulk Data decks control the operations.)

Definition:

name - Name of pseudostructure to be analyzed with NASTRAN.

Notes: 1. Before requesting a SØLVE, the user should check to be sure that all necessary matrices are available on the SØF file. For instance, loads and stiffness matrices are necessary in statics analysis. Mass and stiffness matrices are necessary in eigenvalue analysis, etc.

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5.2 DMAP RULES

Grammatically, DMAP instructions consist of two types: Executive Operation Instructions and Functional Module Instructions. Grammatical rules for these two types of instructions will be discussed separately in subsequent sections.

Functional modules are arbitrarily classified as structural modules, matrix operation modules, utility modules, or user-generated modules.

The DMAP sequence itself consists of a series of DMAP instructions or statements, the first of which is BEGIN or XDMAP and the last of which is END. The remaining statements consist of Executive Operation instructions and Functional Module calls.

5.2.1 DMAP Rules for Functional Module Instructions

The primary characteristic of the Functional Module DMAP instruction is its prescribed format. The general form of the Functional Module DMAP statement is:

```
MØD I1,I2,---,Im/Ø1,Ø2,---,Øn/a1,b1,p1/a2,b2,p2----/az,bz,pz $
```

where MØD is the DMAP Functional Module name,
Ii; i = 1,m are the Input Data Block names,
Øi; i = 1,n are the ØOutput Data Block names,
and ai,bi,pi; i = 1,z are the Parameter Sections.

In the general form shown above, commas (,) are used to separate several like items while slashes (/) are used to separate sections from one another. The module name is separated from the rest of the instruction by a blank or a comma (,). The dollar sign (\$) is used to end the instruction and is not required unless the instruction ends in the delimiter / . Blanks may be used in conjunction with any of the above delimiters for ease of reading.

A functional module communicates with other modules and the executive system entirely through its inputs, outputs and parameters. The characteristics or attributes of each functional module are contained in the Module Properties List (MPL) described in Section 2.4 of the Programmer's Manual and are reflected in the DMAP Module Descriptions that follow in Section 5.3 and in the Module Functional Descriptions contained in Chapter 4 of the Programmer's Manual. The module name is a BCD value (which consists of an alphabetic character followed by up to seven additional alphanumeric characters) and must correspond to an entry in the MPL. A Data Block name may be either a BCD value or null. The absence of a BCD value indicates that the Data Block is not needed for a particular application.

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5.2.1.1 Each Functional Module DMAP statement must conform to the MPL regarding:

1. Name spelling
2. Number of input data blocks
3. Number of output data blocks
4. Number of parameters
5. Type of each parameter

Note: See Sections 5.2.1.3 and 5.2.1.4 for allowable exceptions to these rules.

5.2.1.2 Functional Module Names

The only Functional Module DMAP names allowed are those contained in the MPL. Therefore, if a user wishes to add a module, he must either use one of the User Module names provided (see Section 5.6) or add a name to the MPL. The Programmer's Manual should be consulted when adding a new module to NASTRAN.

5.2.1.3 Functional Module Input Data Blocks

In most cases an input data block should have been previously defined in a DMAP program before it is used. However, there may be instances in which a module can handle, or may even expect, a data block to be undefined at the time the module is initially called. An input data block is previously defined if it appears as an output data block in a previous DMAP instruction, as output from the Input File Processor, any user-input (via Bulk Data Cards) DMI or DTI data block name, or exists on the Old Problem Tape in a restart problem. Although the number of data blocks is prescribed, if any number of final data blocks are null, they may be omitted from the section. For example, the module TABPT, which uses five input data blocks, may be defined by:

```
TABPT  GEØM1,,, // $
```

or

```
TABPT  GEØM1 // $
```

A potentially fatal error message (See Section 5.2.1.7) will be issued at compilation time to warn the user that a discrepancy in the data block name list has been detected. This is also true in the event that a previously undefined data block is used as input. Also, see the "error-level" option on the XDMAP compiler option card which may be invoked by the user to terminate execution in the event of such errors.

DMAP RULES

5.2.1.4 Functional Module Output Data Blocks

In general, a data block name will appear as output only once. However, there are cases in which an output data block may be of no subsequent use in a DMAP program. In such a case the name may be used again, but caution should be used when employing such techniques. Although the number of output data blocks is prescribed, the data block name list may be abbreviated in the manner of Section 5.2.1.3. Potentially fatal error messages will warn the user if possible ambiguities may occur from these usages.

5.2.1.5 Functional Module Parameters

Parameters may serve many purposes in a DMAP program. They may pass data values into and/or out from a module, or they may be used as flags to control the computational flow within the module or the DMAP program. There are two allowable forms of the parameter section of the DMAP instruction. The first explicitly states the attributes of the parameters, while the second is a briefer simplified specification. The general form of the formal parameter section is

/ ai,bi,pi /

where the allowable parameter specifications are:

$ai =$	$\left\{ \begin{array}{l} V \\ C \\ S \end{array} \right.$	Parameter value is variable and may be changed by the module during execution.
	C	Parameter value is prescribed initially by the user and is an unalterable constant.
	S	Parameter is of type V, and will be saved automatically at completion of module. (See description of the SAVE instruction.)
$bi =$	$\left\{ \begin{array}{l} Y \\ N \end{array} \right.$	Initial parameter value may be specified on a PARAM Bulk Data card.
	N	Initial parameter value may <u>not</u> be specified on a PARAM Bulk Data card.
$pi =$	$\left\{ \begin{array}{l} PNAME = v \\ PNAME \\ v \end{array} \right.$	PNAME is a BCD name selected by the user to represent a given parameter.
	$PNAME$	
	v	

The default values for ai and bi depend on the value given for pi, as described below. The three forms available for pi require additional clarification. The symbol 'v' represents an

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actual numeric value for the parameter and may be used only when $a_i = C$ and $b_i = N$. The other forms will be clarified by the examples found at the end of this section. Each parameter has an initial value which is established when the DMAP sequence is compiled during execution of the NASTRAN preface. The means by which initial values are established for all DMAP parameters will be explained by the symbolic examples that follow. The value used at execution time may differ from the initial value if and only if the module changes the value, if $a_i = "V"$, and the parameter name appears in a SAVE (see Section 5.7) instruction immediately following the module.

The formal parameter specifications defined above can, in frequently encountered instances, be greatly simplified. Situations where these simplifications may be used are:

1. `/ C,N,v /` can be written as `/ v /`

The value 'v' is written exactly as it would be in the formal specification with the exception of BCD constant parameters, in which case the BCD string is enclosed by asterisks, i.e., `/ *STRING* /`.

2. `/ V,N,PNAME /` can be written as `/ PNAME /`

`/ V,N,PNAME=v /` can be written as `/ PNAME=v /`

Again, in the case where the value 'v' appears, it is written exactly as in the case of the formal specification. In this case, BCD strings are not delimited by asterisks.

3. `/ (default value) /` can be written as `//`

If a particular parameter has a predefined default value specified in the Module Properties List (MPL), and the user wishes to choose this value, then it is necessary only to code successive slashes. If a parameter does not have a default value, an error message will be issued.

Six parameter types are available and the type of each parameter is given in the MPL and may not be changed. The types and examples of values as they would be written in DMAP are given below:

Parameter Type	Value Examples		
Integer	7	-2	0
Real	-3.6	2.4+5	0.01-3
BCD	VAR01	STRING3	B3R56
Double Precision	2.5D-3	1.354D7	
Complex Single Precision		(1.0,-3.24)	
Complex Double Precision		(1.23D-2,-3.67D2)	

Many possible forms of the parameter section may be used. The following examples will help to clarify the possibilities.

// This is equivalent to `/ C,N,v /` where v is the MPL default value which must exist.

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/ C,Y,v Constant input parameter

Examples: / C,N,0 / C,N,BKLO / C,N,(1.0,-1.0)

or
/ 0 / *BKLO* / (1.0,-1.0)

In the examples shown, both in formal and simplified form, the values 0 (integer), BKLO (BCD), and 1.0-i1.0 (complex single precision) are defined.

/ C,Y,PNAME Constant input parameter; MPL default value is used unless a PARAM Bulk Data card referencing PNAME is present. Error condition is detected if either no PARAM card is present or if no MPL default value exists.

/ C,Y,PNAME=v Constant input parameter; the value v is used unless a PARAM Bulk Data card referencing PNAME is present.

/ V,Y,PNAME	Variable parameter; may be input, output, or both; initial value is the first of
or	1. value from the most recently executed SAVE instruction, if any
/ V,Y,PNAME=v	2. value from PARAM Bulk Data card referencing PNAME will be used if present in Bulk Data Deck
	3. v, if present in DMAP instruction
	4. MPL default value, if any
	5. 0

If a parameter is output from a functional module and if the output value is to be carried forward, a SAVE instruction must immediately follow the DMAP instruction in which the parameter is generated.

```

/ V,N,PNAME      Variable parameter; may be input, output, or both; initial value is the first of
                  or      1. value from the most recently executed SAVE instruction, if any
/ PNAME          2. v, if present in DMAP instruction
                  or      3. MPL default value, if any
/ V,N,PNAME=v    4. 0
                  or
/ PNAME=v

```

5.2.1.6 DMAP Compiler Options - The XDMAP Instruction (see Section 5.7)

The user has the ability to elect several options when compiling and executing a DMAP program by including an XDMAP compiler option instruction in the program. Similarly, the Rigid Formats may be altered by replacing the BEGIN statement with XDMAP to invoke the same options. The available options are:

GØ (default) or NØGØ

The `G0` option compiles and executes the program, while `N0G0` terminates the job at the conclusion of compilation.

LIST or NOLIST (default)

This option produces a DMAP program source listing.

DECK or NODECK (default)

This option will produce a punched card deck of the program.

0SCAR or N00SCR (default)

If the ØSCAR option is selected, a complete listing of the Operation Sequence Control Array will be given.

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REF or NOREF (default)

This option will product a complete cross reference of variable parameters, data block names, and module calls for the DMAP program.

ERR=0 or 1 or 2 (default)

This option specifies the error level, '0' for WARNING, '1' for PØTENTIALLY FATAL, and '2' for FATAL ERRØR MESSAGE, at which termination of the job will occur, see Section 5.2.1.7 for further explanation.

The complete description of the XDMAP card may be found in the DMAP Module Description section.

Note that an XDMAP card need not appear when all default values are elected, but may be replaced with a BEGIN instruction.

5.2.1.7 Extended Error Handling Facility

There are three levels of error messages generated during the compilation of a DMAP sequence. These levels are WARNING MESSAGE, PØTENTIALLY FATAL ERRØR MESSAGE, and FATAL ERRØR MESSAGE. The user has, through available compiler options, the ability to specify the error level at which the job will be terminated. (See Section 5.2.1.6 for the manner of specification.) The class of PØTENTIALLY FATAL ERRØR MESSAGES is generated by certain compiler conveniences which, if not fully understood by the user, could cause an erroneous or incorrect execution of the DMAP sequence. The default value for the error level is that of the FATAL ERRØR.

5.2.2 DMAP Rules for Executive Operation Instructions

Each executive operation statement has its own format which is generally open-ended, meaning the number of inputs, outputs, etc. is not prescribed. Executive operation instructions or statements are divided into general categories as follows:

1. Declarative instructions FILE, BEGIN, LABEL, XDMAP, and PRECHK which aid the DMAP compiler and the file allocator as well as provide user convenience.
2. Instructions CHKPNT, EQUIV, PURGE, and SAVE which aid the NASTRAN Executive System in allocating files, interfacing between functional modules, and in restarting a problem.
3. Control instructions REPT, JUMP, CØND, EXIT, and END which control the order in which DMAP instructions are executed.

The rules associated with the executive operation instructions are distinct for each instruction and are discussed individually in Section 5.7.

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5.2.3 Techniques and Examples of Executive Module Usage

Even though the DMAP program may be interpretable by the DMAP compiler it does not guarantee that the program will yield the desired results. Therefore, this section is provided to acquaint the DMAP programmer with techniques and examples used in writing DMAP programs. In particular, the instructions REPT, FILE, EQUIV, PURGE, and CHPNT will now be discussed in some detail. The DMAP modules available are listed in Section 5.3.

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5.3 INDEX OF DMAP MODULE DESCRIPTIONS

Descriptions of all nonstructurally oriented Modules are contained herein, arranged alphabetically by category as indicated by the lists below. Descriptions for the structurally oriented modules are contained in Section 4 of the Programmer's Manual. They are listed here in order to provide a complete list of all NASTRAN Modules. Additional information regarding nonstructurally oriented modules is also given in Section 4 of the Programmer's Manual.

Matrix Operation Modules (12) (See Section 5.4)

ADD	PARTN
ADD5	SMPYAD
DECOMP	SOLVE
FBS	TRNSP
MERGE	UMERGE
MPYAD	UPARTN

Utility Modules (25) (See Section 5.5)

COPY	PARAMR
DIAGONAL	PRTPARM
INPUT	PVEC
INPUTT1	SCALAR
INPUTT2	SEEMAT
MATGPR	SETVAL
MATPRN	SWITCH
MATPRT	TABPCH
OUTPUT1	TABPRT
OUTPUT2	TABPT
OUTPUT3	TIMESTEST
PARAM	VEC
PARAML	

User Modules (14) (See Section 5.6)

DDR	MDDA
DUMMD1	MDDB
DUMMD2	MDDC
DUMMD3	OUTPUT
DUMMD4	OUTPUT4
INPUTT3	PARTVEC
INPUTT4	XYPRNPLT

Executive Operation Modules (14) (See Section 5.7)

BEGIN	JUMP
CHKPNT	LABEL
CND	PRECHK
END	PURGE
EQUIV	REPT
EXIT	SAVE
FILE	XDMAP

Structurally Oriented Modules (68) (See Section 4 of the Programmer's Manual)

BMG	GPCYC	PLA4	SMA1
CASE	GPFD	PLT	SMA2
CEAD	GP1	PLTSET	SMA3
DDR1	GP2	PLTTRAN	SMP1
DDR2	GP3	PRTMSG	SMP2
DDRM	GP4	RANDM	SSGHT
DPD	GPSP	RBMG1	SSG1
DSCHK	GPWG	RBMG2	SSG2
DSMG1	MCE1	RBMG3	SSG3
DSMG2	MCE2	RBMG4	SSG4
EMA	MTRXIN	READ	TA1
EMG	DFP	RMG	TRD
FA1	OPTPR1	SCE1	TRHT
FA2	OPTPR2	SDR1	TRLG
FRRD	PLA1	SDR2	VDR
GKAD	PLA2	SDR3	XYPLT
GKAM	PLA3	SDRHT	XYTRAN

DIRECT MATRIX ABSTRACTION

In the examples that accompany each description, the following notation is used:

1. Upper case letters and special symbols in the DMAP calling sequence must be punched as shown except for data block names, parameter names, and label names which are symbolic.
2. Lower case letters represent constants whose permissible values are indicated in the descriptive text.

Due to the many possible forms which may be used when writing parameters, a variety of arbitrarily selected forms will be used in the examples. This does not imply that the form used in any example is required or that it is the only acceptable form allowed.

The terms form, type, and precision are used in many functional module descriptions. By form is meant one of the following:

<u>Form</u>	<u>Meaning</u>
1	Square
2	Rectangular
6	Symmetric

By type is meant one of the following:

<u>Type</u>	<u>Meaning</u>
1	Real, single precision
2	Real, double precision
3	Complex, single precision
4	Complex, double precision

By precision is meant one of the following:

<u>Precision Indicator</u>	<u>Meaning</u>
1	Single precision numbers
2	Double precision numbers

DIRECT MATRIX ABSTRACTION

5.5 UTILITY MODULES

<u>Module</u>	<u>Basic Function</u>	<u>Page</u>
COPY	Generate a physical copy of a data block	5.5-2
DIAGONAL	Strip diagonal from matrix	5.5-2a
INPUT	Generate most of bulk data for selected academic problems	5.5-3
INPUTT1	Read data blocks from GINØ-written user tapes	5.5-4
INPUTT2	Read data blocks from FØRTRAN-written tapes	5.5-10
MATGPR	Print Matrices with Grid Point Identification	5.5-13
MATPRN	Print Matrices	5.5-15
MATPRT	Print Matrices associated only with geometric grid points	5.5-16
ØUTPUT1	Write data blocks via GINØ onto user tapes	5.5-17
ØUTPUT2	Write data blocks via FØRTRAN onto user tapes	5.5-24
ØUTPUT3	Punch matrices onto DMI cards	5.5-28
PARAM	Manipulate Parameter values	5.5-30
PARAML	Selects parameters from a user input matrix or table	5.5-32
PARAMR	Performs specified arithmetic, logical and conversion operations on real or complex parameters	5.5-33
PRTPARAM	Print parameter values and DMAP error	5.5-35
PVEC	Substructure Analysis Partitioning Vector Data Generator	5.5-37
SCALAR	Convert Matrix element to parameter	5.5-39
SEEMAT	Generate Matrix Topology Displays	5.5-40
SETVAL	Set parameter values	5.5-43
SWITCH	Interchange two data block names	5.5-43a
TABPCH	Punch NASTRAN tables on DIT cards	5.5-44
TABPRT	Print selected table data blocks using readable format	5.5-45
TABPT	Print table data blocks	5.5-47
TIMETEST	Provides NASTRAN system timing data	5.5-48
VEC	Generate partitioning vector	5.5-49

Utility modules are an arbitrary sub-division of the Functional Modules and are used to output matrix and table data blocks and to manipulate parameters.

The data block names corresponding to the various matrix and table data blocks used in the Rigid Format DMAP sequences may be found in Section 3 or in the NASTRAN mnemonic dictionary, Section 7.

DIRECT MATRIX ABSTRACTION

- I. NAME: COPY
- II. PURPOSE: To generate a physical copy of a data block.
- III. DMAP CALLING SEQUENCE:
COPY DB1 / DB2 / PARAM \$
- IV. INPUT DATA BLOCKS:
DB1 - Any NASTRAN data block
- V. OUTPUT DATA BLOCKS:
DB2 - Any valid NASTRAN data block name
- VI. PARAMETERS:
PARAM - If $PARAM < 0$ the copy will be performed - integer, input, default = -1.
- VII. METHOD: If $PARAM \geq 0$ a return is made, otherwise a physical copy of the input data block is generated.
- VIII. REMARKS:
 1. The input data block may not be purged.

UTILITY MODULES

- I. NAME: `DIAGØNAL` (Strip diagonal from matrix)
- II. PURPOSE: To remove the real part of the diagonal from a matrix, raise each term to a specified power, and output a column vector or square symmetric matrix.
- III. DMAP CALLING SEQUENCE:
`DIAGØNAL A/B/C,Y,ØPT=CØLUMN/V,Y,PØWER=1. $`
- IV. INPUT DATA BLOCKS:
A - can be any square or diagonal matrix.
- V. OUTPUT DATA BLOCKS:
B - is either a real column vector or symmetric matrix containing the diagonal of A.
- VI. PARAMETERS:
`ØPT` - Input-bcd, default=`CØLUMN`
 =`'CØLUMN'` - produces column vector output (labeled as a general rectangular matrix)
 =`'SQUARE'` - produces square matrix (labeled a symmetric matrix)
`PØWER` - Input-real single precision, default = 1. Exponent to which the real part of each diagonal element is raised.
- VII. REMARKS:
1. The module checks for special cases of `PØWER=0.0, 0.5, 1.0, and 2.0`.
2. The precision of the output matrix matches the precision of the input matrix.

UTILITY MODULES

- I. NAME: SETVAL (Set Values)
- II. PURPOSE: Set DMAP Parameter variable values equal to other DMAP Parameter variables or DMAP Parameter constants.
- III. DMAP CALLING SEQUENCE:
- ```
SETVAL // V,N,X1 / V,N,A1 /
 V,N,X2 / V,N,A2 /
 V,N,X3 / V,N,A3 /
 V,N,X4 / V,N,A4 /
 V,N,X5 / V,N,A5 $
```
- IV. INPUT DATA BLOCKS: None
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS:
- |                    |                                                              |
|--------------------|--------------------------------------------------------------|
| X1, X2, X3, X4, X5 | Output, integers, variables                                  |
| A1, A2, A3, A4, A5 | Input, integers; default values = 1, variables or constants. |
- VII. METHOD: This module sets X1 = A1, X2 = A2, X3 = A3, X4 = A4, and X5 = A5. Only two parameters need be specified in the calling sequence (X1 and A1).
- VIII. REMARKS:
1. A SAVE instruction must immediately follow the SETVAL instruction if the output parameter values are to be subsequently used.
  2. See PARAM for an alternate method of defining parameter values.
  3. As an example, the statements  
SETVAL // V,N,X1 / V,N,A1 / V,N,X2 / C,N,3 \$  
SAVE X1,X2 \$  
are equivalent to the statements  
PARAM // C,N,ADD / V,N,X1 / V,N,A1 / C,N,0 \$  
PARAM // C,N,NOP / V,N,X2=3 \$

## DIRECT MATRIX ABSTRACTION

- I. NAME: SWITCH
- II. PURPOSE: To interchange two data block names.
- III. DMAP CALLING SEQUENCE:  
SWITCH DB1,DB2 // PARAM \$
- IV. INPUT DATA BLOCKS:  
DB1 } Any NASTRAN data blocks  
DB2 }
- V. OUTPUT DATA BLOCKS: None
- VI. PARAMETERS:  
PARAM - If PARAM < 0 the switch will be performed - integer, input, default=-1.
- VII. METHOD: If PARAM  $\geq 0$  a return is made, otherwise the names of the data blocks are interchanged. All attributes of the data within the blocks remains constant, only the names are changed.
- VIII. REMARKS:  
1. Neither input data block may be purged.  
2. This option is of use in iterative DMAP operations.

## DIRECT MATRIX ABSTRACTION

I. NAME: TABPCH (Table Punch)

II. PURPOSE: To punch NASTRAN tables onto DTI cards in order to allow transfer of data from one NASTRAN run to another, or to allow user postprocessing.

III. DMAP CALLING SEQUENCE:

TABPCH TAB1,TAB2,TAB3,TAB4,TAB5 // C,N,A1 / C,N,A2 / C,N,A3 / C,N,A4 / C,N,A5 \$

IV. INPUT DATA BLOCKS:

TAB1

TAB2

TAB3 Any NASTRAN Tables

TAB4

TAB5

V. OUTPUT DATA BLOCKS:

None - All output is punched onto DTI cards.

VI. PARAMETERS:

A1, A2, A3, A4, A5 -- Input - BCD - Defaults are 'AA', 'AB', 'AC', 'AD', 'AE'. These parameters are used to form the first two characters (columns 74, 75) of the continuation field for each table respectively.

VII. REMARKS:

1. Any or all tables may be purged.
2. Integer and BCD characters will be punched onto single-field cards. Real numbers will be punched onto double-field cards. Their formats are I8, 2A4, E16.9.
3. Up to 99,999 cards may be punched per table.
4. Currently, twice the entire record must fit in open core.
5. Tables with 1 word BCD values (ELSETS) cannot be punched correctly.

VIII. EXAMPLES:

TABPCH EST,,,, // C,N,ES \$ will punch the EST onto cards with a continuation mnemonic of +ES<sub>bbbb</sub>i (where i is the sequence number).

## DIRECT MATRIX ABSTRACTION

### 5.7 EXECUTIVE OPERATION MODULES

| <u>Module</u> | <u>Basic Function</u>                                       | <u>Page</u> |
|---------------|-------------------------------------------------------------|-------------|
| BEGIN         | Always first in DMAP; begin DMAP program                    | 5.7-2       |
| CHKPNT        | Write data blocks on checkpoint tape if checkpointing       | 5.7-3       |
| CØND          | Conditional forward jump                                    | 5.7-4       |
| END           | Always last in DMAP; terminates DMAP execution              | 5.7-5       |
| EQUIV         | Assign another name to a data block                         | 5.7-6       |
| EXIT          | Conditional DMAP termination                                | 5.7-7       |
| FILE          | Defines special data block characteristics to DMAP compiler | 5.7-8       |
| JUMP          | Unconditional forward jump                                  | 5.7-9       |
| LABEL         | Defines DMAP location                                       | 5.7-10      |
| PRECHK        | Predefined automated checkpoint                             | 5.7-10a     |
| PURGE         | Conditional data block elimination                          | 5.7-11      |
| REPT          | Repeat a series of DMAP instructions                        | 5.7-12      |
| SAVE          | Save value of output parameter                              | 5.7-13      |
| XDMAP         | Controls the DMAP compiler options                          | 5.7-14      |

All modules classified as Executive Operation Modules are individually described in this section. Additional discussions concerning the interaction of the Executive Modules with themselves and with the NASTRAN Executive System are contained in Section 5.2.3.

## DIRECT MATRIX ABSTRACTION

- I. NAME: BEGIN (Begin DMAP Program)
- II. PURPOSE: BEGIN is a declarative DMAP instruction which may be used to denote the beginning of a DMAP program.
- III. DMAP CALLING SEQUENCE:  
BEGIN \$
- IV. REMARKS:
  1. BEGIN is a non-executable DMAP instruction which is used only by the DMAP compiler for information purposes.
  2. Either a BEGIN card or an XDMAP card is required when selecting APP DMAP in the Executive Control Deck. This is followed by DMAP instructions up to and including the END card.
  3. The use of BEGIN implicitly elects all compiler defaults. (See XDMAP instruction.)

## EXECUTIVE OPERATION MODULES

I. NAME: CHPNT (Checkpoint)

II. PURPOSE: Causes data blocks to be written on the New Problem Tape (NPTP) to enable the problem to be restarted with a minimum of redundant processing.

III. DMAP CALLING SEQUENCE:

CHPNT D1,D2,...,DN \$

where D1,D2,...,DN ( $N \geq 1$ ) are data blocks to be copied onto the problem tape for use in restarting problem.

IV. RULES:

1. A data block to be checkpointed must have been referenced in a previous PURGE, EQUIV, or functional module instruction.
2. CHPNT cannot be the first instruction of a DMAP loop.
3. Data Blocks generated by the Input File Processor (including DMI's and DTI's) should not be checkpointed since they are always regenerated on restart.
4. Checkpointing only takes place when a New Problem Tape (NPTP) is set up and the Executive Control Card CHPNT YES appears in the Executive Control Deck. Otherwise, the CHPNT instructions are ignored.
5. For each data block that is successfully checkpointed, a card of the restart dictionary is punched which gives the critical data for the data block as it exists on the Problem Tape.
6. For data blocks that have been purged or equivalenced, an entry is made in the restart dictionary to this effect. In these cases data blocks are not written on the Problem Tape.

V. REMARKS:

1. See the PRECHK instruction for an automated CHPNT capability.

## DIRECT MATRIX ABSTRACTION

I. NAME: CØND (Conditional Transfer)

II. PURPOSE: To alter the normal order of execution of DMAP modules by conditionally transferring program control to a specified location in the DMAP program.

III. DMAP CALLING SEQUENCE:

CØND n,V \$

where:

1. n is a BCD label name specifying the location where control is to be transferred. (See the LABEL instruction.)
2. V is a BCD name of a variable parameter whose value indicates whether or not to execute the transfer. If  $V < 0$  the transfer is executed.

IV. EXAMPLE:

BEGIN \$

CØND L1,K \$

MØDULE1 A/B/V,Y,P1 \$

LABEL L1 \$

MØDULEN X/Y \$

END \$

If  $K \geq 0$ , MØDULE1 is executed. If  $K < 0$  control is transferred to the label L1 and MØDULEN is executed.

V. REMARKS:

Only forward transfers are allowed. See the REPT instruction for backward transfers.

## EXECUTIVE OPERATION MODULES

- I. NAME: END (End DMAP Program)
- II. PURPOSE: Denotes the end of a DMAP program.
- III. DMAP CALLING SEQUENCE:  
END \$
- IV. NOTES:
  1. The END instruction also acts as an implied EXIT instruction.
  2. The END card is required whenever the analyst selects APP DMAP in his Executive Control Deck.



## DIRECT MATRIX ABSTRACTION

I. NAME: EQUIV (Data Block Name Equivalence)

II. PURPOSE: To attach one or more equivalent (alias) data block names to an existing data block so that the data block can be referenced by several equivalent names.

III. DMAP CALLING SEQUENCE:

EQUIV DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB \$

Note: The number of data block names (DBNij) prior to each parameter (PARMj) and the number of such groups in a particular calling sequence are variable.

IV. INPUT DATA BLOCKS:

DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence. The 1st data block name in each group (DBN1A and DBN1B in the examples above) is known as the primary data block and the 2nd, etc. data block names become equivalent to the primary (depending on the associated parameter value). These equivalenced data blocks are known as secondary data blocks.

V. OUTPUT DATA BLOCKS: (None specified or permitted)

VI. PARAMETERS:

PARMA, etc. - One required for each set of data block names.

VII. METHOD: The data block names in each group are made equivalent if the value of the associated parameter is  $< 0$ . If a number of data blocks are already equivalenced and the parameter value is  $\geq 0$ , the equivalence is broken and the data block names again become unique. If the data blocks are not equivalenced and the parameter value is  $\geq 0$ , no action is taken.

VIII. REMARKS:

1. An EQUIV statement may appear at any time as long as the primary data block name has been previously defined.
2. If an equivalence is to be performed at all times, i.e., the parameter value is always negative, it is not necessary to specify a parameter name. For example,

EQUIV DB1,DB2 // DB3,DB4 \$

## EXECUTIVE OPERATION MODULES

- I. NAME: PRECHK (Predefined Automated Checkpoint)
- II. PURPOSE: To allow the user to specify a single, or limited number, of checkpoint declarations thereby removing the need for a large number of individual CHPNT instructions to appear in a DMAP program.
- III. DMAP CALLING SEQUENCE:  
PRECHK name list \$  
PRECHK ALL \$  
PRECHK ALL EXCEPT name list \$  
  
where name is a list of data block names separated by commas and not exceeding 50 data blocks per command .
- IV. REMARKS:
  1. PRECHK is, in itself, a non-executable DMAP instruction which actuates the automatic generation of explicitly CHPNT instructions during the DMAP compilation.
  2. Any number of PRECHK declarations may appear in a DMAP program. Each time a new statement is encountered the previous one is invalidated. The PRECHK END \$ option will negate the current PRECHK status.
  3. CHPNT instructions may be used in conjunction with PRECHK declarations. The CHPNT instruction will override any PRECHK condition. For example, if the PRECHK ALL EXCEPT option is in effect, a data block named in the excepted list may still be explicitly CHPNTed.
  4. PRECHK automatically CHPNTs all output data blocks from each functional module or purge instruction, and all secondary data block of an EQUIV instruction.

## EXECUTIVE OPERATION MODULE

I. NAME: PURGE (Explicit Data Block Purge)

II. PURPOSE: To flag a data block so that it will not be assigned to a physical file.

III. DMAP CALLING SEQUENCE:

PURGE DBN1A,DBN2A,DBN3A / PARMA / DBN1B,DBN2B / PARMB \$

Note: The number of data block names (DBN<sub>ij</sub>) prior to each parameter (PARM<sub>j</sub>) and the number of groups of data block names and parameters in a particular calling sequence is variable.

IV. INPUT DATA BLOCKS:

DBN1A,DBN2A, etc. - Any data block names appearing within the DMAP sequence.

V. OUTPUT DATA BLOCKS: (None specified or permitted)

VI. PARAMETERS:

PARMA, etc. - One required for each group of data block names.

VII. METHOD: The data blocks in a group are purged if the value of the associated parameter is  $< 0$ . If a data block is already purged and the parameter value is  $\geq 0$ , the purged data block is unpurged so that it may be subsequently reallocated. If the data block is not purged and the parameter value is  $\geq 0$ , no action is taken.

VIII. REMARKS:

1. If a purge is to be made at all times, i.e., the parameter value is always negative, it is not necessary to specify a parameter name. For example,

PURGE DB1,DB2,DB3,DB4 \$

## DIRECT MATRIX ABSTRACTION

I. NAME: REPT (Repeat)

II. PURPOSE: To repeat a group of DMAP instructions a specified number of times.

III. DMAP CALLING SEQUENCE:

REPT n,c \$ or REPT n,p \$

where:

1. n is a BCD name appearing in a LABEL instruction which specifies the location of the beginning of a group of DMAP instructions to be repeated. (See LABEL instruction.)
2. c is an integer constant hard coded into the DMAP program which specifies the number of times to repeat the instructions.
3. p is a variable parameter set by a previously executed module specifying the number of times to repeat the instructions.

IV. EXAMPLE:

BEGIN \$

.

LABEL L1 \$

MODULE1 A/B/V,Y,P1 \$

.

MODULE N B/C/V,Y,P2 \$

REPT L1,3 \$

.

END \$

or

BEGIN \$

.

MODULE1 X/Y/V,Y,NL00P \$

LABEL L1 \$

MODULE1 A/B/V,Y,P1 \$

.

MODULE N B/C/V,Y,P2 \$

REPT L1,NL00P \$

.

END \$

V. REMARKS:

1. REPT is placed at the end of the group of instructions to be repeated.
2. When a variable number of loops is to be performed as in the second example above, the value of the variable at the first time the REPT instruction is encountered will determine the number of loops. This number will not be changed after the initial assignment.
3. A C0ND (conditional jump) instruction may be used to exit from the loop if desired.
4. In the first example, the instructions MODULE1 to MODULE N will be repeated three times (i.e., executed four times).

## EXECUTIVE OPERATION MODULE

I. NAME: SAVE (Save Variable Parameter Values)

II. PURPOSE: To specify which variable parameter values are to be saved from the preceding functional module DMAP instruction for use by subsequent modules.

III. DMAP CALLING SEQUENCE:

SAVE V1,V2,...,VN \$

where the V1,V2,...,VN (N > 0) are the BCD names of some or all of the variable parameters which appear in the immediately preceding Functional Module DMAP instruction.

IV. REMARKS:

1. A SAVE instruction must immediately follow the functional module instruction wherein the parameters being saved are generated.
2. See Section 5.2.1.5 for a description of the alternate method of saving parameter values by means of the parameter specification statement.

## DMAP MODULE DESCRIPTIONS

- I. NAME: XDMAP (Execute DMAP Program)
- II. PURPOSE: To control the DMAP compiler options.
- III. DMAP CALLING SEQUENCE:

XDMAP {  $\begin{matrix} G\emptyset \\ N\emptyset G\emptyset \end{matrix} \}$  , {  $\begin{matrix} ERR = 0 \\ ERR = 1 \\ ERR = 2 \end{matrix} \}$  , {  $\begin{matrix} LIST \\ N\emptyset LIST \end{matrix} \}$  , {  $\begin{matrix} DECK \\ N\emptyset DECK \end{matrix} \}$  , {  $\begin{matrix} \emptyset SCAR \\ N\emptyset \emptyset SCR \end{matrix} \}$  , {  $\begin{matrix} REF \\ N\emptyset REF \end{matrix} \}$

where:

- $G\emptyset$  - compile and execute program (default)
- $N\emptyset G\emptyset$  - compile only and terminate job.
- ERR - defines the error level at which suspension of execution will occur
  - ERR = 0 Warning error level
  - 1 Potentially Fatal error level
  - 2 Fatal error level (default)
- LIST - a listing of the DMAP program will be printed.
- $N\emptyset LIST$  - no listing (default)
- DECK - a deck of the DMAP program will be punched.
- $N\emptyset DECK$  - a deck will not be punched (default)
- $\emptyset SCAR$  - detailed listing of  $\emptyset SCAR$  (Operation Sequence Control Array), the output of the DMAP compiler.
- $N\emptyset \emptyset SCR$  - no  $\emptyset SCAR$  listing (default)
- REF - a cross reference listing of the program will be printed.
- $N\emptyset REF$  - no cross reference (default)

#### IV. REMARKS:

1. The XDMAP card is optional and may be replaced by a BEGIN instruction. But, one or the other MUST appear in an APP DMAP execution.
2. The XDMAP instruction is non-executable and is used to control the above options by the DMAP compiler.
3. If all defaults are chosen the instruction need not appear, use BEGIN instead.
4. The DMAP compiler option defaults can also be overridden with DIAG 14 (DMAP listing), DIAG 17 (punch DMAP deck), and DIAG 4 ( $\emptyset SCAR$  listing) in the Executive Control Deck. However, the option summary, printed before the DMAP source, will not change to reflect DIAG selections.

## DIRECT MATRIX ABSTRACTION

### 5.8 EXAMPLES

In order to facilitate the use of DMAP, several examples are provided in this section. The user is urged to study these examples both from the viewpoint of performing a sequence of matrix operations and that of a DMAP flow. In addition, some examples have been written to illustrate the improved DMAP syntax.

#### 5.8.1 DMAP Example

##### Objective

1. Print the contents of table data block A.
2. Print matrix data blocks B, C, and D.
3. Print values of parameters P1 and P2.
4. Set parameter P3 equal to -7.

|         |                           |         |                     |
|---------|---------------------------|---------|---------------------|
| BEGIN   | \$                        | XDMAP   | \$                  |
| TABPT   | A,,, // \$                | TABPT   | A // \$             |
| MATPRN  | B,C,D,, // \$             | MATPRN  | B,C,D // \$         |
| PRTPARM | // C,N,0 / C,N,P1 \$      | PRTPARM | // 0 / *P1* \$      |
| PRTPARM | // C,N,0 / C,N,P2 \$      | PRTPARM | // 0 / *P2* \$      |
| PARAM   | // C,N,NØP / V,N,P3=-7 \$ | PARAM   | // *NØP* / P3=-7 \$ |
| END     | \$                        | END     | \$                  |

##### Remarks:

1. To be a practical example, a restart situation is assumed. The user is cautioned to remember to reenter at DMAP instruction 2 by changing the last reentry point in the restart dictionary.
2. In the alternate form, the omission of trailing commas in the TABPT and MATPRN instructions will generate POTENTIALLY FATAL ERROR messages alerting the user to possible errors in the data block name list.

## DIRECT MATRIX ABSTRACTION

### 5.8.2 DMAP Example

Let the constrained matrix  $[K_{\ell\ell}]$  and the load vector  $\{P_{\ell}\}$  be defined by means of DMI bulk data cards. The following DMAP sequence will perform the series of matrix operations

$$\{u_1\} = [K_{\ell\ell}]^{-1}\{P_{\ell}\}$$

$$\{r\} = [K_{\ell\ell}]\{u_1\} - \{P_{\ell}\}$$

$$\{\delta u\} = [K_{\ell\ell}]^{-1}\{r\}$$

$$\{u_2\} = \{u_1\} + \{\delta u\}$$

Print  $\{u_2\}$

|                                                                                                                                                                                                                                              |    |                                                                                                                                                                                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <pre> BEGIN      \$ SOLVE     KLL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 \$ MPYAD     KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 \$ SOLVE     KLL,R / DU / C,N,1 \$ ADD       U1,DU / U2 \$ MATPRN    U2,,,, // \$ END        \$         </pre> | or | <pre> XDMAP     \$ SOLVE     KLL,PL / U1 / 1 / 1 / 1 / 1 \$ MPYAD     KLL,U1,PL / R / 0 / 1 / -1 \$ SOLVE     KLL,R / DU / 1 \$ ADD       U1,DU / U2 \$ MATPRN    U2 // \$ END        \$         </pre> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

#### Remarks:

1.  $[K_{\ell\ell}]$  is assumed symmetric.
2. In the example above, KLL will be decomposed twice. A more efficient DMAP sequence, which requires only a single decomposition for this problem is given below.

|                                                                                                                                                                                                                                                                         |    |                                                                                                                                                                                                                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <pre> BEGIN      \$ DECOMP    KLL / LLL,ULL \$ FBS       LLL,ULL,PL / U1 / C,N,1 / C,N,1 / C,N,1 / C,N,1 \$ MPYAD     KLL,U1,PL / R / C,N,0 / C,N,1 / C,N,-1 \$ FBS       LLL,ULL,R / DU \$ ADD       U1,DU / U2 \$ MATPRN    U2,,,, // \$ END        \$         </pre> | or | <pre> XDMAP     \$ DECOMP    KLL / LLL,ULL \$ FBS       LLL,ULL,PL / U1 / 1 / 1 / 1 / 1 \$ MPYAD     KLL,U1,PL / R / 0 / 1 / -1 \$ FBS       LLL,ULL,R / DU \$ ADD       U1,DU / U2 \$ MATPRN    U2 // \$ END        \$         </pre> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



## EXAMPLES

### 5.8.9 DMAP Example to Compute the r-th Power of a Matrix [Q]

```

BEGIN $
MATPRN Q,,, // $
PARAM // C,N,NØP / V,N,TRUE=-1 $
PARAM // C,N,SUB / V,N,RR / V,Y,R=-1 / C,N,2 $
PARAM // C,N,NØP / V,N,FALSE=+1 $
ADD Q, / QQ $
LABEL DØIT $
EQUIV QQ,P / FALSE $
MPYAD Q,QQ, / P / C,N,0 $
EQUIV P,QQ / TRUE $
PARAM // C,N,SUB / V,N,RR / V,N,RR / C,N,1 $
CØND STØP,RR $
REPT DØIT,1000000 $
LABEL STØP $
MATPRN P,,, // $
END $

```

or

```

BEGIN $
MATPRN Q // $
PARAM // *SUB* /, RR / V,Y,R=-1 / 2 $
CØPY Q / P $
LABEL TØP $
MPYAD Q,P / PP / 0 $
SWITCH P,PP // $
REPT TØP,RR $
MATPRN P // $
END $

```

#### Notes:

1. The matrix [Q] is assumed input via DMI bulk data cards.
2. The parameter R is assumed input on a PARAM bulk data card.
3. A logical flow diagram for this DMAP is shown in the following sketch.
4. The improved DMAP to perform the same operation can be done with substantially fewer commands.

# DIRECT MATRIX ABSTRACTION

